Equals

Realising potential in mathematics for all

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Bar Modelling
How many toy cars do they have altogether?

Equals

Realising potential in mathematics for all

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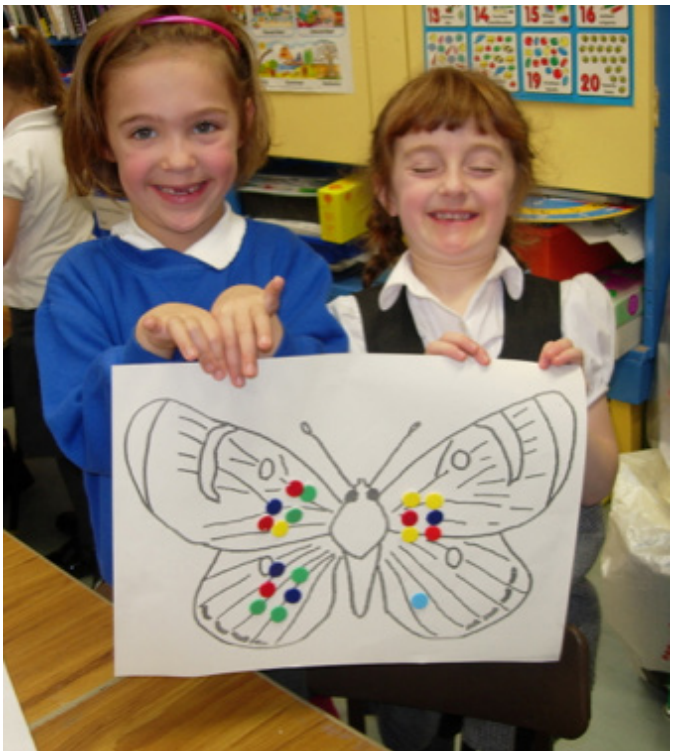
Designed by Nicole Lane

Editors' Page

Reading Louise Langford's article gave me the strangest sense of déjà vu! As I write my family is getting ready for the celebrations associated with my eldest daughter's twenty first birthday. She is now coming to the end of fifteen years of formal education yet right at the start, when she was in Year 1, I used an approach very similar to that so very well articulated by Louise. Indeed the photograph of the dots on the wings of the butterfly bear an uncanny resemblance to the work my daughter and her friends produced all those years ago, as you can see below!



My own introduction to this 'number sense' was through the Let's Think Math's resource published by GL Assessment. Please get in touch if you use similar approaches to early number work in your school as the words of Louise highlight just how important such an approach could be in supporting the mathematical reasoning of all children;

"*Starting with dots has supported Elle to 'see' patterns and develop patterns systematically, enabling her to start to justify her thinking. For example, Elle quickly grasped how to use counters to support her in 'bridging through ten' and independently chose to use counters to support her thinking when 'bridging through twenty'. Observations in lessons showed her increasing use of visualisation and dot patterns to support number sense. Therefore, this approach has been particularly effective in supporting Elle to visualise and internalise dot patterns, developing automaticity of key facts through using multi-sensory experiences to aid memory.*"

This edition of *Equals* is composed mainly of articles we have received in response to our last two editions which is really good news for us and shows increasing levels of participation from colleagues who are passionate about SEND. My daughters have both been heavily involved in netball since Year 4 and the slogan used among netballers is 'Pass on your passion!' I wonder if we can apply that to *Equals* and ask that you 'Pass on your passion for SEND' and share with us something that you use, or do, to support and develop mathematical thinking. An example of this is the interview with Jodie Allonby of St Peter's

RC Academy in Middlesbrough. Jodie is a nurture group teacher who has a real passion for her Year 7 and 8 students. Having visited her classroom on many occasions I was keen to share part of her story through *Equals*. Similarly the piece by Daniel Blundred complements this well as he reflects how his own thinking has changed regarding SEND provision within mathematics. Please get in touch if you know of a colleague like Daniel or Jodie whose voice needs to be heard.

With so many colleagues coming forward to share what they are doing to support SEND in their classrooms it could be that the time is right for an *Equals* conference. If you would be willing to take part in such an event or have ideas that you would like to share then could you please let us know so we can assess the demand across the country for a conference of this nature. If we feel there is enough interest then we will inform you on the MA website and in our Spring edition.

Starting with dots!

Inspired by the Spot on with Number piece written by Carol Handyside, that we published in July, Louise Langford shares her own experience of using such an approach to early number recognition.

My fascination with 'dots' began several years ago when I had the opportunity to train as a Dyscalculia Specialist. At the time I was a Numbers Count teacher working with a range of students experiencing difficulties in learning mathematics, some had specific needs such as Dyslexia or Cognition and learning, some were suffering from maths anxiety or had missed teaching. However, one or two students seemed to struggle with mathematics significantly even though they were achieving year group expectations in other subjects. This inspired me to want to find out more about Dyscalculia which is a specific mathematical learning difficulty thought to affect approx 6% of students within our schools-https://www.bdadyslexia.org.uk/dyslexic/maths-difficulties-dyscalculia.

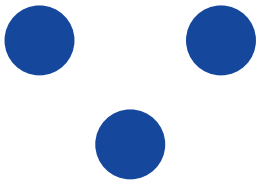
There is not one fixed definition of dyscalculia but a general agreement that dyscalculic learners have specific difficulties with number sense, understanding number patterns and relationships and recalling number facts, which can then cause difficulties with developing calculation skills. In addition, those with dyscalculia do not have the ability to subitise, that is the ability to rapidly count or determine the number of objects in a small collection. This is an important mathematical skill

Without a secure sense of number, students will struggle.

as it supports the development of number sense, enabling students to understand the magnitude of a number, see numbers as composites of parts and as a whole as well as using numbers flexibly. Furthermore, learners often have problems manipulating numbers visually in their heads in order to complete tasks such as sequencing numbers or applying patterns to reason mathematically. This can be a real difficulty as patterns are central to the number system and mathematical reasoning. Indeed, number sense lays the foundations for future learning. Without a secure sense of number, students will struggle.

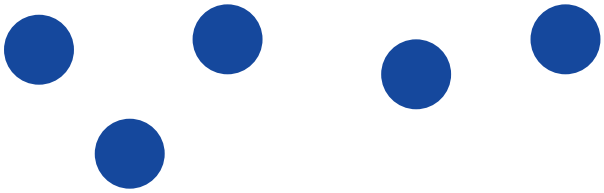
Subitising is a fascinating skill. Have you ever tried to quickly identify a small amount of objects?

Put your hand over these dots and ask a friend to say how many they can see when you quickly reveal them.



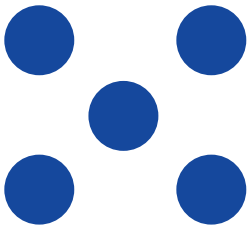
Most people will say 3. This is perceptual subitising or 'just knowing' the amounts.

Now have another go. How many? What do you see?



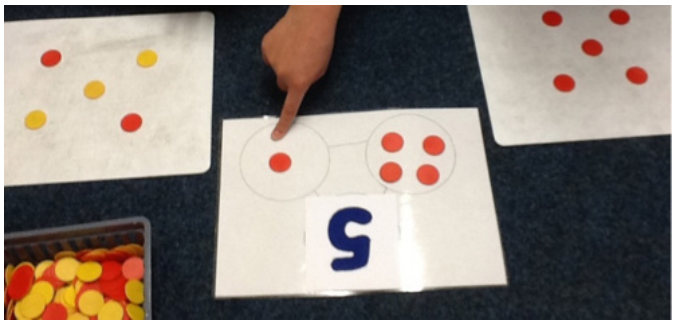
This question can induce a range of answers: 2 and 2 and 1, 5, 3 and 2 more etc…This is known as conceptual subitising where amounts are decomposed into recognisable amounts that can be recomposed to make the whole.

If I now rearrange those counters into the dice 5, it's more instantly recognisable.



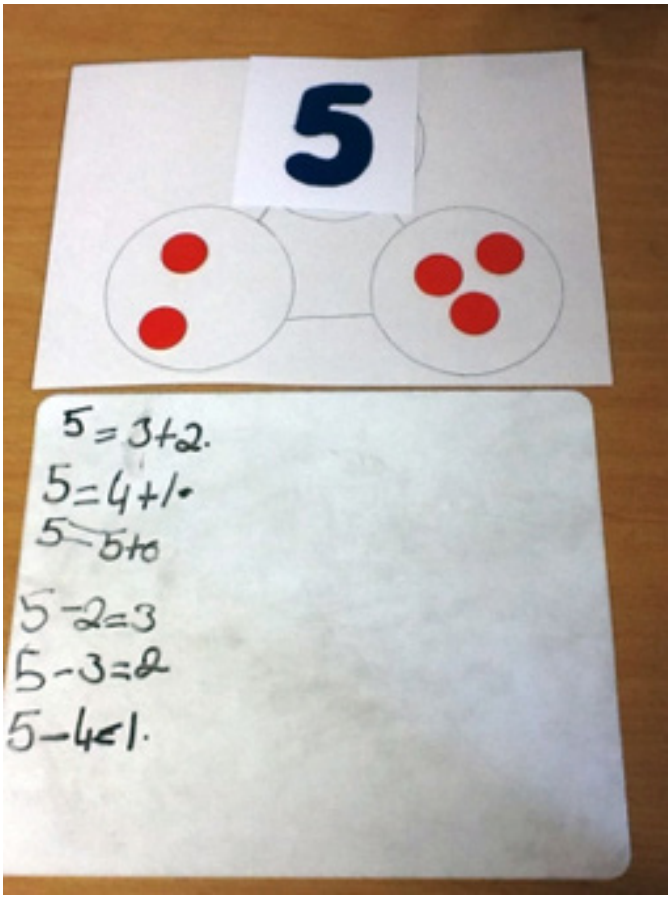
Most people can subitise up to 5 or 6 items and use grouping to count up to 10. Subitising is an innate skill humans have; it's also believed that some animals can do this. Research suggests that although dyscalculics appear to have an inability to subitise, with regular practice they can learn. In fact many experts in the field of dyscalculia recommend using 'dice patterns' as a method of teaching (Butterworth and Yeo, 2004, Chinn 2012, Emerson and Babtie, 2014, Sharma 2019). As by organising dots into patterns, memory load is reduced and amounts become more memorable.

The students I worked with all struggled with mathematics and a few had potential indicators of dyscalculia so I was aware of the importance of using a multi sensory approach to teaching dot patterns. Multi sensory learning involves students using more than one sense and having the opportunity to move from concrete to abstract through internalising key models, images and patterns that support their understanding, whilst verbalising their strategies to assist processing and memory.



One of the resources I was shown on my Dyscalculia course (Edge Hill University) was a set of number cards 0-10 made using felt numerals on one side and felt dot dice patterns on the other side.

One of my Year 5 students, Elle, demonstrated possible indicators of dyscalculia, had specific difficulties with processing and memory but was able to subitise up to five. We made 'feely' cards together, which Elle absolutely loved, in order to support her in knowing the cardinality of a number and learn number bonds. Elle was able to use her ability to subitise up to five to 'see' facts within the patterns and therefore learn to partition the dots in different ways and reason through counting, comparing and grouping. By placing less demand on her memory she could manipulate more than one set of dots to calculate.



By placing less demand on her memory she could manipulate more than one set of dots to calculate.

We then went on to place the dots on a part/part/whole diagram to expose the relationship between addition and subtraction. By placing the dots (or counters) on the triad diagram and manipulating them, she was able to understand the connection between addition and subtraction facts. Through butterfly printing she explored doubles and halves then went on to investigate near doubles using two coloured counters.

Starting with dots has supported Elle to 'see' patterns and develop patterns systematically, enabling her to start to justify her thinking. For example, Elle quickly grasped how to use counters to support her in 'bridging through ten' and independently chose

to use counters to support her thinking when 'bridging through twenty'. Observations in lessons showed her increasing use of visualisation and dot patterns to support number sense. Therefore, this approach has been particularly effective in supporting Elle to visualise and internalise dot patterns, developing automaticity of key facts through using multi-sensory experiences to aid memory.

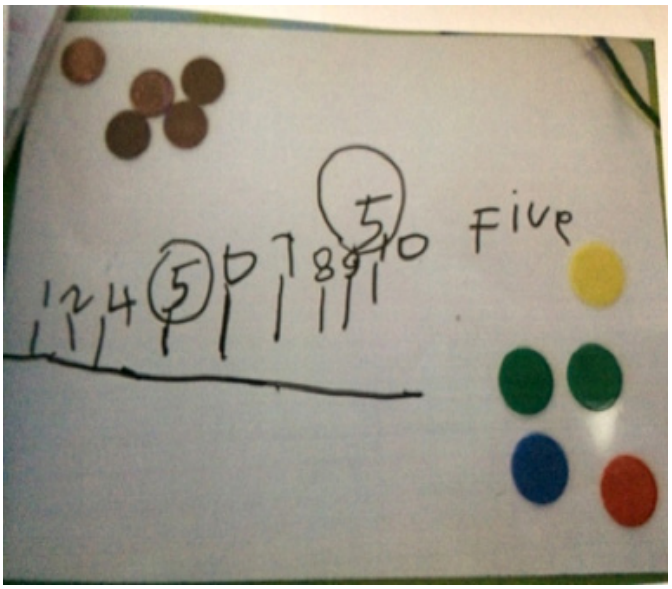
As a Work Group Lead for the SHaW Maths Hub Hereford group- Developing working partnership for SEND and mathematics, I wanted to share this work on using subitising to develop number sense as I felt it may be a useful strategy for all learners. On Day 1 we began to explore barriers to learning, key concepts in mathematics and lesson task design. Part of Day 1 involved exploring number sense, how it underpins many mathematical concepts, the importance of number sense in developing fluency and how to develop this important aspect of mathematical understanding. We looked at subitising, dice patterns and Tens Frames. At the end of this day participants were asked to complete a gap task, thinking about the students they teach, could they begin to identify barriers to learning and adapt lesson tasks to overcome that barrier? This led to the start of some fantastic action research, which in many cases continued over the year. The participants chose an area relevant to their students and setting, which resulted in the exploration of a variety of representations and using multi-sensory resources to engage learners. The feedback from this task was really interesting with common themes emerging:

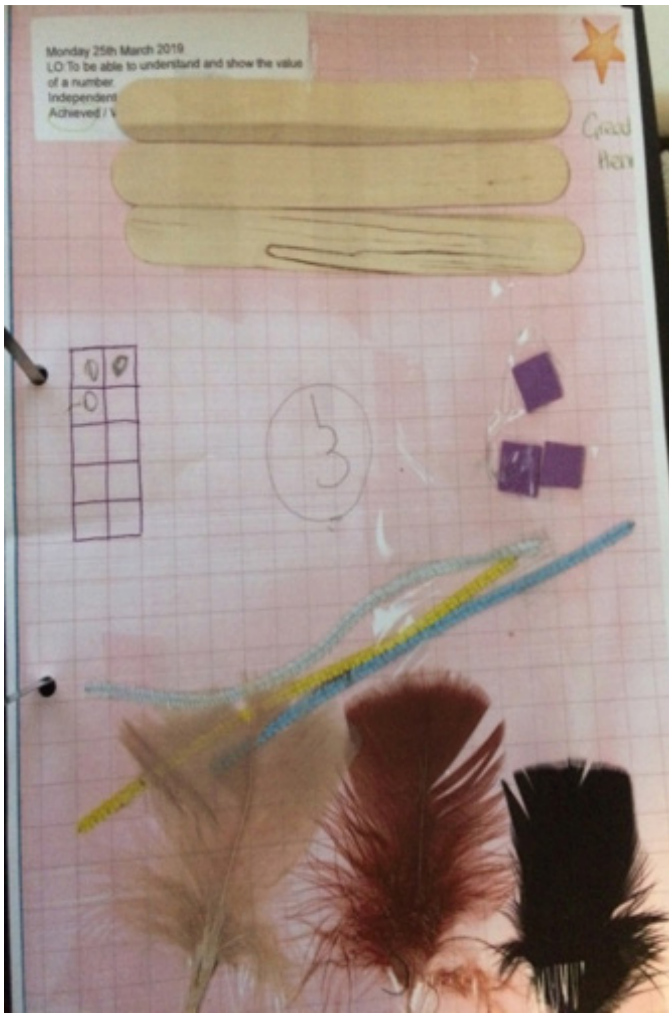
- All students were able to access learning through the use of concrete resources which showed some were not as secure as expected whereas others could now access greater depth,
- Mathematical language improved,
- Mixing representations was really effective in developing understanding and engaging learners.

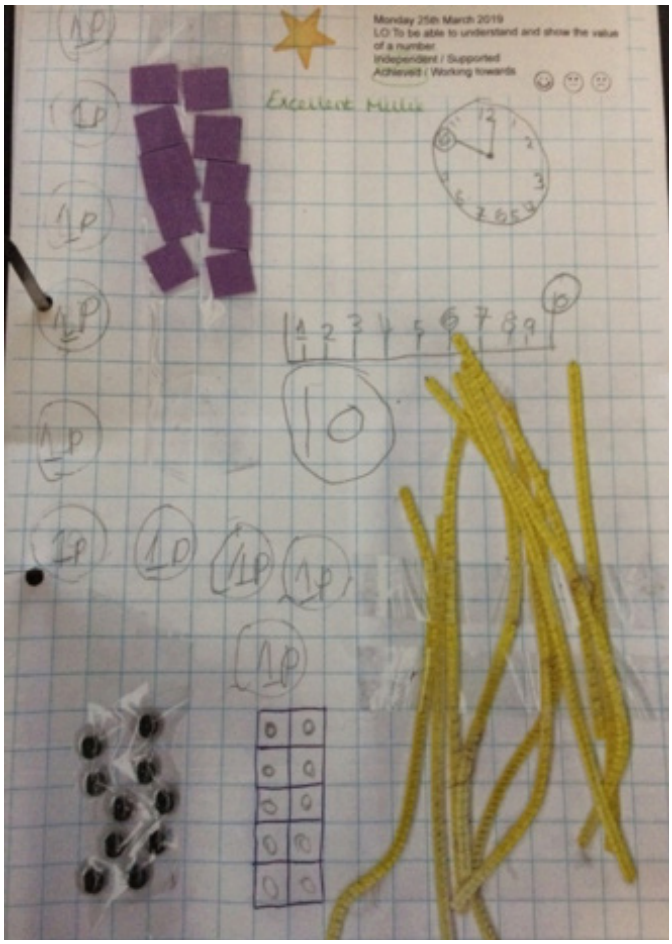
Mixing representations was really effective in developing understanding and engaging learners

One gap task relevant to this research I would like to share is from Emma Norman at Westfield School. She focused on a KS3 student with specific SEND who didn't understand numbers to 5. Emma encouraged her student to make numbers using a variety of different equipment in a range of contexts.

This really supported the student's thinking, enabling them to identify, match, write and sequence numbers to 5. Emma noted that this student was more engaged, enjoying learning and would now independently find small quantities







to show the value of each number. They would regularly go and collect objects to support finding the value of a given number, this is a huge achievement! Emma really believes they have been able to develop and retain these numbers through the activities she developed based around dot patterns. She then went on to make and introduce a wider variety of practical resources to teach number with the whole class, finding that

other students can now access the tens frame and link numbers to the five wise pattern.

Furthermore, Emma felt she was now able to encourage reasoning, question the students about their approach and the process they took, as well as develop more multi sensory teaching.

Starting with dots has certainly proved to be successful in my experience, engaging the learner, offering opportunities for mathematical discussion and discovery whilst supporting connections being made within different aspects of mathematics. This gives the learner a real sense of achievement, supports them in remembering key facts and enables them to build a bank of effective calculation strategies. I hope this has sparked your interest and if you would like to find out more I would recommend:

Butterworth, B and Yeo, D. (2004) *Dyscalculia Guidance: Helping pupils with specific learning difficulties in maths*. London: NFER-Nelson.

Chinn, S. (2012) *The trouble with maths*. 2nd Ed, Abingdon: Routledge.

Clements (1999) Subitizing: What is it? Why teach it? Teaching Children Mathematics NCTM

Emerson, J and Babtie, P. (2014) *The Dyscalculia Solution foreword by Butterworth*. London: Bloomsbury Education.

Online resources by Mahesh C. Sharma President of Mathematics for All, USA

Louise Langford

The Education Inspection Framework

Mark Pepper has taken the time to review the new framework for inspection with one eye on the needs of SEND pupils – thanks Mark.

Education Inspection Framework 2019 (EIF): Can teachers comply with the spirit of promoting autonomy and deep understanding for their learners as well as successfully meeting the demands that exist within the official exam process?

There has been a heavy, though not unanimous, consensus that the new Ofsted Framework will be beneficial to teachers in the belief that the strong focus on exam results will be replaced by a consideration of the more general development of the students and that this will significantly reduce the amount of time that teachers would be required to take on bureaucratic tasks. An example of this interpretation of the Framework was published in The Times (22 June 2019).

“The new framework is a radical departure from the existing system. Schools will be judged more

on the breadth of their curriculum and quality of teaching and learning than their exam results, which hold sway at present."

Amanda Spielman, Chief Inspector of Ofsted, is a strong advocate of a more progressive education policy than that that existed under her predecessor, Michael Wilshaw. In a recent lecture presented at the Royal Society she made clear her view that extensive time spent by schools in preparing students for undertaking formal exams should be replaced by a much broader curriculum that encouraged the overall development and greater autonomy of the students.

She demonstrated her strong opposition to "teaching to the test" in *"How Ofsted is trying to tackle the culture of teaching to the test"*.

John Roberts (2018) quotes Amanda Spielman as referring to the new Framework as being a "warning shot across the bows for schools that are getting good results through something that no sane parent would want as an education for their child."

Misgivings regarding workload for schools

The former Education Secretary, Damian Hinds, has expressed his belief that the new Framework will lead to an increase in workload. This fear has been echoed by the leaders of both of the head teachers unions, The National Association of Head Teachers and The Association of School and College Leaders.

The effects of the new framework within the context of maths

The focus from this point onwards will exclusively consider the effects of the inspection framework within mathematics with an emphasis on the primary sector. An example of the general approach to current inspections is contained in the EIF guidance under the sub-heading Personal Development (para 28):

"The curriculum extends beyond the academic, technical or vocational. It provides for learners' broader development, enabling them to develop and discover their interests and talents."

"The curriculum extends beyond the academic, technical or vocational. It provides for learners' broader development, enabling them to develop and discover their interests and talents."

Whilst these assertions are to be welcomed, in the section entitled Impact it is made clear that exam results will continue to be considered within the inspection process (p.10):

"Learners develop detailed knowledge across the curriculum and, as a result, achieve well. *Where relevant, this is reflected in results from national tests and examinations that meet government expectations, or in the qualifications obtained.*" My italics.

Misgivings regarding the way in which inspections will be carried out

Mary Bousted, general secretary of the National Education Union, gives a warning against the belief that inspections will no longer take into account the results of formal exam results:

"Ofsted is not proposing to abandon data on KS2 SATS results, the phonic tests and, in time, the times table test and baseline assessment."

inspectors should give credit for lessons that encourage elaboration, deep learning, reasoning and critical thinking

Anne Watson, in her Royal Society blog (2019), acknowledges that the mathematics-specific guidance within the Framework specifies that inspectors should give credit for lessons that encourage elaboration, deep learning, reasoning and critical thinking. She goes on to express doubts whether non-specialist inspectors will have the mathematical knowledge to make such an assessment and she poses the question:

"Is it going to be safe to teach lessons using an "elaboration" approach while being observed by non-specialist inspectors?"

Will the current Ofsted inspection framework be compatible with the existing assessment procedure?

Consideration will be made of this within the context of Year 6 Mathematics National Tests (NTs) With the introduction of the 2016 NTs there was much rhetoric to the effect that they consisted of a switch to a more problem solving approach. A close examination of the content of the 2016 tests (and subsequent tests) reveals that in reality the total reverse of this is true. (Pepper 2018)

The main changes from 2015 to 2016 can be summarised as follows:

A total ban on the use of calculators throughout all of the papers.

The introduction of an Arithmetic Paper in which the entire paper consists of questions involving the knowledge of number facts and the application of taught algorithms.

The withdrawal of the mental maths paper.

A sharp increase in the inclusion of questions involving short and long multiplication and division questions.

Furthermore there were significant changes to the instructions contained in the marking scheme.

In the 2016 tests and in subsequent tests the following instruction is provided:

"Award two marks for the correct answer…if the answer is incorrect, award one mark for the formal method of division with no more than one mathematical error."

Compare this with the instructions contained in the marking scheme instructions for the 2015 Paper:

"Calculations, formulae and written responses do not have to be set out in any particular format… Any correct method of setting and working, however idiosyncratic, will be accepted."

Contradictions in Ofsted expectations for maths teachers

Primary teachers are faced with the following dilemma. On the one hand they are required to demonstrate that they are teaching in a manner congenial to the development of autonomy and the use of diverse methods of calculation. At the same time they are under constant pressure to obtain acceptable results from their learners. If they do not teach the formal method within multiplication and division questions they sacrifice the possibility of an additional mark for its use in National Tests. Hence they are placed in an impossible position.

The current Ofsted framework is not compatible with the present assessment process.

Similarly in future they will be under pressure to facilitate their pupils in achieving acceptable results in the forthcoming tables tests and this will inevitably involve rote learning. Hence on both counts they can be accused of "teaching to the test", which has been condemned by Ofsted.

If they do teach within the spirit of active learning and as a consequence their pupils achieve unsatisfactory NT results then they will be penalised.

Contradictions between expectations contained in the Ofsted framework and the content of NTs

The current Ofsted framework is not compatible with the present assessment process. This conflict could be resolved if Ofsted liaised with the authors of the NTs in order to reach an agreement on ways in which Ofsted inspections could complement the content of the NTs. This could be achieved by designing future NTs such that the format reverted back to that which was in existence prior to 2016. Hence the mental maths paper would be restored and the arithmetic paper would be abolished. In at least one of the papers use of a calculator would be permitted. A range of open ended questions could be included that would facilitate an assessment of the problem solving ability and creativity of the candidate. Questions involving short and long multiplication and division could be greatly reduced and the availability of an additional mark for the use of the formal method withdrawn.

Strategies that could be put in place to reform the maths curriculum

If there is a genuine desire by Ofsted to transform the maths teaching in schools from the heavy reliance on rote learning and the application of taught algorithms to one which aims to promote

the autonomy, creativity and problem solving abilities of the learners then the following policies could be introduced:

Retain the mathematics National Curriculum but crucially re-instate AT 1 Using and applying.

Amend the format and content of the NTs as outlined above.

Encourage the use of calculators where appropriate.

Encourage the regular use of mental maths in an interactive setting.

Devise teaching policies that are in accordance with the directives contained in the Cockcroft Report.

Perhaps most important – make maths lessons enjoyable.

Mark Pepper

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Education Inspection Framework. 2019. Crown Copyright

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Watson A (2019) What's likely to go wrong using the mathematics-specific guidance that goes with the draft Ofsted Framework. The Royal Society blog

Roberts J (2018) Need to know: Ofsted's new inspection framework. *TES*

Pepper M (2018) Key Stage 2 Mathematics Curriculum National Tests One step forward or 5 steps back? *Primary Mathematics* Spring 2018 Volume 22 Issue no. 1

Key Stage 2 Tests: Mathematics Test Materials. *Key Stage 2 Tests: 2017 Mathematics Test Materials*. Crown Copyright

Timely Practice

Lesley Goddard **follows up her recent piece on memory and retention with an in-depth focus upon the benefits of 'timely practice' as a tool to support learning.**

Low attaining learners tend to have;

(1) shorter long-term memory duration and,

(2) smaller working memories

than their peers. Each must be addressed if we wish low attaining learners to close the learning gap between themselves and their more highly attaining peers. We cannot change these per se, so instead we must teach in a way to help our learners overcome the limitations of each.

I'll explain the mechanisms for extending each and then go on to explain how timely practice enables teachers to enable low attaining learners to make dramatic improvements in learning mathematics by ensuring that learning becomes deeply embedded rather than quickly forgotten.

Increasing the depth of learning

Increasing the duration of the learner's long-term memory can be done;

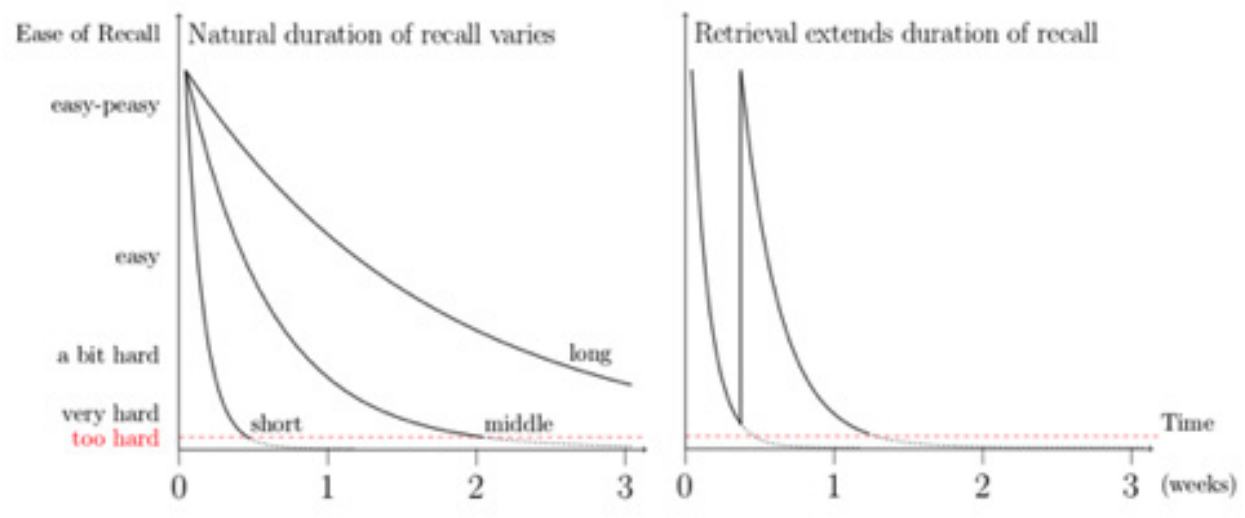
(i) at the point of teaching by facilitating learners to attach new learning to existing learning;

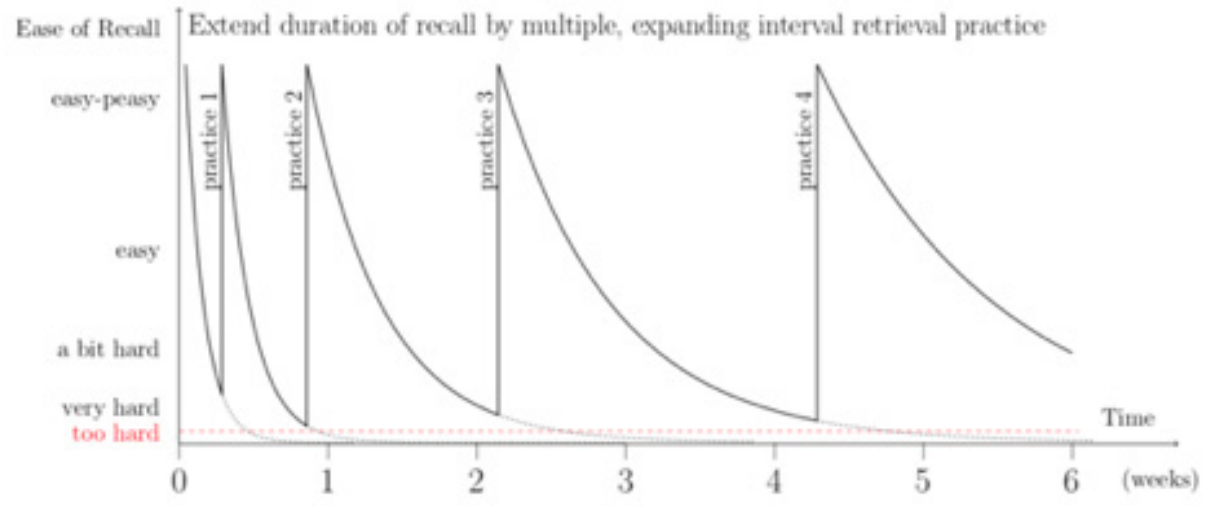
(ii) after the point of teaching by repeated retrieval practice. This will increase the duration of the learners long-term memory for the practised skills.

In a traditional lesson and scheme of learning format we tend to rely on overlearning to increase the retention of learning, however Krueger[1929] has demonstrated that this has limited efficacy. Overlearning is practising beyond one successful solving of a problem type and although it does increase retention, for each extra practice question the learner embeds that learning progressively less, until soon there is no further improvement.

Overlearning is to teaching what cramming is to revision, if you will. Neither is particularly effective, as we are not waiting for "enough forgetting to happen" before we practice another question. With retrieval practice we deliberately wait for "enough forgetting to happen" between one practice and the next. Having to "think a little" in order to recall, deepens the memory. We know biologically that the more heavily used connections in the brain are coated in thicker layers of myelin, which speeds up these connections. Bromley, M 2005

What we don't know biologically (yet) is the exact mechanism to trigger the thickening of the myelin … but we can infer what to do in teaching to trigger this process. We know that practising something "easy to recall" doesn't change the length of retention Krueger1929, it seems that this is because there is no trigger to deepen the connections in long-term memory. We know that practising something "desirably difficult Bjork 2011" does increase the length of time we can remember that something before we forget it. It seems to me that we can condense this to a simple statement "the brain only bothers to strengthen connections when it feels it needs to". We can make answering a question, "desirably difficult" at the point of teaching by e.g. a matching exercise or a hard to read font; and after the point of teaching by waiting until sufficient forgetting has happened so retrieving the required skills is "a little challenging".





The wait between one practice and the next can increase in a geometric sequence. For low attaining learners, we have found that $w_n = ar^n$ works well, where and w is the wait between one practice and the next, $1 \leq a \leq 3$ days and $1.6 < r \leq 1.8$

Increasing the effective size of working memory

Working memory is precious, learners have 4 ± 1 slots in working memory[Cowan 2001]. When learners practice similar but slightly different problems over time, i.e. with expanding interval retrieval practice, they cumulatively create stronger connections within their long-term memory. These connections are said to form a chunk Gobet 2005 or a mental schema Sweller 2011, the chunk is the useful cluster of stronger connections in memory which help the learner solve the problem. The brain can use these chunks instead of some of the working memory slots. Hence deliberate practice can "effectively increase" the slots available to the learner in working memory. Gobet 2005

Here is a simple example of "effectively increasing" working memory. If I asked you to remember K N U H C you might need 5 slots in working memory, to remember CHUNK you only need one slot in working memory as the chunks which enable you to read reduce your working memory requirement. In terms of teaching and learning maths, I'll consider teaching a set of procedures where each is stand alone, but I think it will be clear that the arguments will be as applicable, if not more so when teaching cumulative skills.

Typical problems for low attaining learners learning the procedures to calculate the statistics mean, median, mode and range are (i) forgetting to order the data items before finding the median (which is a typical working memory overload symptom: forgetting parts of procedures) and (ii) not being able to match the name of each statistic with the correct method (this could be a working memory overload symptom - muddling procedures - or it could be due to short long-term memory, i.e. not being able to remember for long enough).

With a traditional units-of-related-topics, each-topic-once-a-year scheme of learning we tend to teach several statistics within a lesson and "fade the scaffolding" within the lesson. Learners start

the lesson being able to refer to the white board or a crib sheet showing examples of each, and as the lesson progresses the learners must refer to this less. The problem with this method is that learners tend to forget steps, or combine partial procedures together because the fading happens too fast on insecure learning foundations.

However if after teaching each new statistic we use retrieval practice to embed learning sufficiently before teaching the next statistic, then muddling is unlikely occur and can be fixed by feedback on the rare occasions when it does. If we stick with an annual scheme of learning, learners will make slow but steady progress. By the end of year 11 all learners will be able to independently and accurately apply each procedure.

However the learner would not have a chance to close the gap with their peers as there would not be sufficient time to learn calculating statistics from a frequency table nor from grouped data. If we break away from the somewhat arbitrary once a year requirement of the "units-of-related-topics, each-topic-once-a-year" scheme of learning, we could teach a new objective say once a term. This would allow 3 more years to teach how to apply these statistics to frequency tables and with grouped data.

Annual	Statistic objective	Termly
Year 7	Mode	Year 7 term 1
Year 8	Range	Year 7 term 2
Year 9	Median with an odd number of data items	Year 7 term 3
Year 10	Median with an even number of data items	Year 8 term 1
Year 11	Mean	Year 8 term 2

What I am suggesting is that we teach less at one time and return to topics more frequently in order to enable low attaining learners to be able to accurately build their chunks or mental schema. In doing so teachers can enable learners to overcome the debilitating effect of having a smaller working memory capacity within an educational system set up for learners with average or above average working memory capacity.

teach less at one time and return to topics more frequently

The timely practice app

Timely practice has 4 unique selling points all directed to ensuring maximum embedded learning for low attaining learners:

(1) increase duration of each learner's long-term memory. Learners retain and can apply their learning in tests and exams but more importantly, learners prior learning forms firm learning foundations for future learning.

(2) increase the effective size of working memory. Learners can learn more harder maths.

(3) ensure that teachers only provide feedback when it can be applied by the learner - i.e. can be remembered for long enough to be

applied.

(4) tracking depth of learning rather than merely what has been taught. The app tracks the depth of learning of the "small bites" of learning, which enables the teacher to only teach "new learning" when the learners are ready to learn it.

Each of these enables previously low attaining learners to learn and retain much more maths within the existing lesson footprint. In the following section I'll explain in more detail, what is currently going wrong for low attaining learners and what timely practice does to fix it.

many low attaining learners forget new learning within 2 to 5 days

(1) long-term memory

What is going wrong: Our experience tells us that many low attaining learners forget new learning within 2 to 5 days. At the moment it is common for low attaining learners to learn almost the same work from a topic every year for several years of their secondary education and still not be able to recall or apply that learning when they take their GCSE. Revision programs are not very effective as, what the teacher feels is revision, seems to the learners as "new learning".

How timely practice fixes this: With a relatively modest number of similar but different practice questions, a "forgets within 3 days learner" can become a "remembers for over a year learner", provided the questions are timed appropriately, hence the name "timely practice". We use a repeated retrieval system, where the spacing between one practice and the next expands exponentially provided the learner can independently and accurately answer their most recent practice question. There is time for retrieval practice, i.e. practice after the point of teaching because (i) less practice is done at the point of teaching, (ii) there is little to no repeating of teaching year on year (iii) learners are more engaged in problem solving so they tend to work faster in class.

More specifically: The teacher asks the timely practice app to create a pdf document for each learner containing the most urgent mixed [Rohrer, D. 2009] retrieval practice questions. The learners spend about 15 minutes, at least 3 times a week doing their timely practice assignment. The teacher assessment options for each question (independent and accurate, oops or feedback) is used by the app to adjust the spacing of future practice. We ask the teacher to use the answers provided by the app - so the teacher's sole focus is on assessment for learning.

(2) working memory

What is going wrong: Our experience also tells us that if we try to teach "too much" from a topic at one time, the learner will get stuck in a practice -> require help -> forget loop. This is because if the learner's working memory is fully utilised in remembering and applying the procedures for one skill from a topic there is no spare working memory capacity to learn another skill from the same topic. The learner hasn't had a chance to build the chunk [Gobet 2005] or a mental schema [Sweller

[2011] for the skill (which could have reduced some of the working memory requirement), before being asked to learn another similar skill (or worse another skill which uses the not fully embedded skill). This results in typical working memory overload problems and so the new learning is either not embedded deeply in long-term memory or it is embedded very inefficiently.

Often the new learning, let alone any help or feedback, is not remembered by the learner

How timely practice fixes this: We split up learning into smaller "bites" - which we call layers. Usually 2 or 3 of our layers form what might be taught in a traditional maths lesson. Layers are designed so that learners can quickly embed chunks of learning within long-term memory through retrieval practice of similar but different questions [Gobet 2005]. Our aim is that the chunks formed in learning the pre-requisite skills can be used to enable new skills to be learned without overloading working memory. The long-term memory can then begin to form chunks from the pre-requisite skill's chunks i.e. chunks of chunks. New skills may be learned, which otherwise could not be, because working memory would without the chunks or chunks of chunks, become overloaded.

We know that without feedback, learners and especially low attaining learners, will not make the progress that they otherwise could.

More specifically: We suggest teachers only teach one layer from each topic at one time. The teacher may return to teach more from the topic once this layer is mastered, 3 layers may be taught from a topic in one academic year. The Resources link from www.timelypractice.com shows how each topic is broken down into layers. We invite teachers to think about a low attaining learner that they teach, and imagine the progress the student could make if they could learn 3 layers per year from each topic.

(3) feedback

What is going wrong: Feedback is not given at a time when it can be useful to the learner because after teaching some new learning from the topic the learner does not return to practice that learning for some time. Often the new learning, let alone any help or feedback, is not remembered by the learner, so the teacher's and learners' time is largely wasted. We know that without feedback, learners and especially low attaining learners, will not make the progress that they otherwise could.

Kluger, A. N., & DeNisi, A. 1996.

How timely practice fixes this: We ensure that the feedback the teacher gives can be applied by the learner "the next time the learner meets a similar problem". When the learner needs feedback, we reduce the spacing between the practice of problems from a layer, so that the learner can remember the feedback for long enough to apply it.

More specifically: We make sure there will be

sufficient lesson time and teacher capacity to do feedback, as most of the learners, most of the time can independently and accurately answer their timely practice questions. While the other learners are "doing their timely practice" - and embedding that learning more deeply - the teacher can interrupt each learner "to do feedback". The feedback is nearly always one to one, in the form of a dialogue which may also involve the teacher modelling the solution on the learner's pdf assignment.

learners, especially when they feel they are being tested tend to copy

(4) tracking

What is going wrong: Tracking of maths learning for low attaining learners has several problems (i) it tracks how effectively teaching seemed in a lesson rather than how durable that learning is; (ii) the tracking is often of "too large a bite" of learning, since low attaining learners generally can't learn such a large bite at one time, we end up tracking partially learned "bites"; (iii) the tracking data generally is based on "one question asked and answered" but from our research we know that this can give a false positive about 20% of the time; (iv) finally learners, especially when they feel they are being tested tend to copy, so either data is based on copying or we stress out the learners by enforcing test conditions - both lead to inaccurate data. Tracking of teaching is not assessment for learning.

The teacher can see whether the learning of a layer is fragile, improving or mastered and can use this to plan teaching.

How timely practice fixes this: We track embedded learning, how long the app "guesses" the learner will be able to retain each layer. We call this measure the depth of learning, it is measured in days and is a proprietary measure based upon many questions asked and answered, so although a guess it is a very informed guess. Using depth of learning to decide if the pre-requisites are mastered is valuable assessment for learning.

More specifically: We enable the teacher to see the depth of learning of each layer for each learner within the colour coded progress on topic page. The teacher can see whether the learning of a layer is fragile, improving or mastered and can use this to plan teaching.

Getting maximum embedded learning per lesson

For timely practice to work as it is designed to i.e.

- each learner to spend about 15 minutes per lesson, at least three times a week, doing their personalised timely practice assignment,
- learners learn smaller "bites" of learning, each usually takes under 20 minutes to teach and practice,
- learners get one to one feedback when they need it
- we suggest a maximum class size.

We have found that 16 learners per teacher is comfortable. If there is a learning support teacher consistently working with the teacher (i.e. every lesson) then the class could be up to 26 learners. The two "pinch points" on teacher time are

(1) outside of lesson assessment: about 1 minute per learner at least 3 times a week (to compensate, lesson planning is very quick and learning resources are provided for each layer);
(2) inside of lesson feedback : feedback on 0 to 3 questions per student per lesson.

Teachers who have followed our guidelines say they are proud of their and their learners success and they "wouldn't want to go back to teach low attaining learners the old way" because "nothing else works for low attaining learners". They say they would be dissatisfied to "go back to teaching the same thing to the same learners for several years in a row".

they are proud of their and their learners success

"nothing else works for low attaining learners"

Currently we are looking to recruit more schools to our free trial, as we need more learners using timely practice in order to statistically prove that timely practice works as well as we say it does.

Please contact me, Lesley Goddard via www.timelypractice.com if you are interested in finding out more, watching timely practice in action or want to try timely practice to enhance the effectiveness of your teaching.

Lesley Goddard

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Number Stacks

Louise Needham asked **James Aylott** to write about the resource he has been developing that we feel deserves a much wider place in SEND provision. Please get in touch with James if you would like to know more but can you let *Equals* know how you use this resource.

NUMBER STACKS – Supporting Children at School and at Home

Just over a year ago, I left my job as a primary Headteacher to have a go at something I had always wanted to do - create a new maths intervention program that ticked all the boxes I was looking for when I was a primary maths lead. 12 months on and we are amazed at the positive feedback we have received from our early adopters and in particular, those working with children who have special educational needs (such as dyscalculia) or have suffered maths anxiety in the past. In this article I'll try to provide a rundown of what Number Stacks is and the reasons behind its creation.

What is Number Stacks?

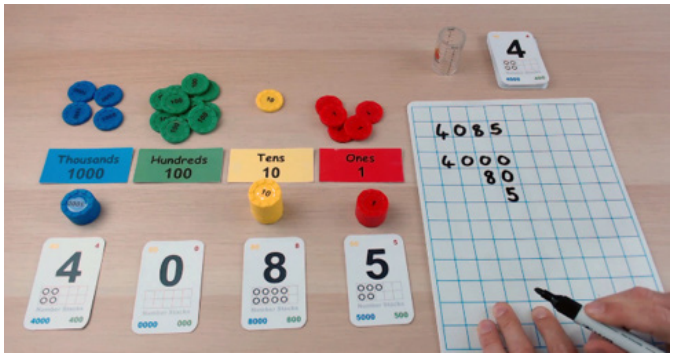
Number Stacks is made up of two main elements: physical resource kits and online video tutorials. As a primary maths leader, I was always on the look out for something to support those children who found maths difficult and needed a bit of extra help grasping new concepts. We had introduced concrete resources into maths lessons throughout the school including dienes blocks, Numicon and place value counters and were using the CPA approach (Concrete, Pictorial, Abstract) in our units of work. Pupils who struggled with concepts initially, definitely found it easier when they had the concrete resources to help them so I knew that any additional support had to have manipulatives at its foundation.

I knew that any additional support had to have manipulatives at its foundation

Now I was aware that maths support programmes using manipulatives already existed but I found that there was a common issue with them – the instructions! Often, an adult would be required to read 2 to 3 pages of text to explain what activities they were supposed to do with the children they were supporting. Not only was this time wasted

in my opinion, it also led to the possibility of the instructions being misinterpreted. What is clear in the writer's mind is not always easily transferred in written word and when you couple this with the fact that adults in primary schools are usually not specialists in any particular subject (you have to be a bit of a 'Jack of all trades') it could often take longer to prepare for a session than to actually deliver it! This is why I decided that Number Stacks would only use video tutorials that the adult and child would watch together to explain each new concept, meaning NO wasted preparation time and NO misinterpretations! Also, the videos only use equipment provided in the resource kits so there is NO searching around for particular items before a session (provided you keep the kit together in a safe place!).

Resource Kit



Video Tutorial

What skills are covered?

It is often the case that children who struggle to grasp a new concept have gaps in their early number development which need to be addressed. Key skills need to be broken down into small, manageable steps with a clear, logical pathway that builds upon the skill before it. Unlike some interventions, I didn't want Number Stacks to be a temporary sticking plaster or to use 'quick wins' such as shape & space objectives in order to show some progress. After much thought (and many drafts) I settled on a list of 69 Key Skills separated into 5 sections: Number & Place Value, Addition & Subtraction; Multiplication & Division; Fractions; and Decimals. Initial assessments for each section identify starting points and children need to be confident in all skills up to the desired age range in one section before moving on to the next in the order written above.

The Stackable Place Value Counters:

Out of the concrete resources that were being used throughout the school, my personal preference was the place value counters. Don't get me wrong, there is a need for children to use a range of manipulatives to represent numbers, particularly in their younger years but what struck me about place value counters was their versatility in being great for developing Early Number Sense but also being used in the older classes to represent more complex calculation methods. After teaching many lessons myself using standard counters, I found that working areas could get messy quite quickly which sometimes led to children not knowing whether a counter was part of their number or not. I had often said that it would be great if the counters could be stacked in some way as it would keep the working area more organised and also help children identify when a

place value column was ‘full’ (e.g. ten 1s) and an exchange needed to happen. This is where the idea of our stacking counters was born! Our users have commented on the thickness of our counters which makes them easier for smaller hands to handle and the stacking element is also brilliant for developing fine motor skills meaning you can work on two skills at once!

Reducing Maths Anxiety in Children AND Parents

After months filming, editing and uploading video tutorials to my website, it quickly became apparent that what had initially started out as an intervention for schools to support struggling pupils, had become an all-round resource that parents could use at home as well. Watching the video tutorials together with their child means that absolutely no prior knowledge is needed so anyone can help their child at home. In fact, a large proportion of our users are parents who are working with their own children to develop and re-build confidence in maths and the feedback we have received has been quite incredible! Many have gone right back to basics and worked through the Number & Place Value skills and described how their children now say that maths is ‘fun’, ‘makes sense’ and ‘they ask to do more’. By breaking everything into small, manageable steps visually in our videos and using concrete resources, many barriers are broken down and maths starts to become accessible to children of all ages and abilities.

What’s Next?

Once gaps in mathematical understanding have been addressed, it is important that they aren’t forgotten. Over time, children may forget what they have learnt unless it is practised. There are a number of games ideas on our website that our members can play with their children in order to revisit and consolidate key skills in a fun way. Work is also underway on a ‘Fluency Question Generator’ where a particular year group and strand can be selected and questions will be displayed at random to help children remember the essential skills from prior year groups.

Basically, it will be like a set of 1000 flash cards on your device that you won't need to shuffle and sort yourself!

Another area I am investigating is 'Goal-Free Problem Solving'. If the 'right / wrong' element is removed from a problem, then children are often much more willing to have a go and explore the information and language involved in problem solving. It would be great to have a set of these problems for each of the Number Stacks Key Skills so children could apply their fluency but at the moment, this is a project for the future!

It has been a whirlwind first year and thanks to the power of social media, Number Stacks has spread as far as USA, New Zealand and Australia where we have sent kits and have parents using Number Stacks effectively with their children. Knowing that my work is helping to make maths accessible and enjoyable to hundreds of children is immensely satisfying and I am looking forward to what the next 12 months may bring. Thanks for reading.

James Aylott – Creator of Number Stacks.

If you want to find out more about Number Stacks, visit our website at www.numberstacks.co.uk or email us at supprt@numberstacks.co.uk

SEND Provision at Ormiston Meridian Academy

Daniel Blundell has a great passion for the SEND pupils in his school. In this piece he outlines both how his own thinking has developed and also the systems they have put in place to ensure that all pupils receive the help they need with mathematics.

You can see how engaged the Ormiston pupils are by watching the following video that Daniel has included as part of his article: https://share.icloud.com/photos/0hdH1itGlZNVYtjrqBgARJ_tg

Supporting and Inspiring SEND Students in Maths

If you would have said to me two years ago that I would be teaching Maths and, more importantly, that I would have developed a real passion for the subject, I would have questioned your sanity. Having taught History for nine years previous and had a relatively uninspiring experience of Maths in my last three years at secondary school, teaching Maths was certainly not something that I thought was on the horizon as my career in teaching developed.

Fast forward two years and I am entering my second year teaching Maths full time across KS3 and KS4 and I can honestly say I have never enjoyed being in the classroom as much

as I do now. I will always harbour a love for Humanities subjects, particularly History, however since switching my allegiances I have a greater understanding of the importance of developing numeracy skills for all learners in order to underpin success in later life.

I now have a real commitment to ensuring I work towards this every time I step foot in the classroom and have committed a lot of time to take part in as much subject specific CPD as possible, as well as reading widely around Mathematical pedagogy. In particular, Craig Barton's, 'How I wish I'd taught Maths' and Emma McCrea's 'Making every maths lesson count' have been particular sources of help, support and inspiration. The wealth of information in these books has led me to think about reducing cognitive overload, how to motivate students in maths and how to focus thinking. In addition I have also developed new practice when it comes to modelling, questioning and providing feedback. The 'isolate the skill' section in Emma's book and the 'silent teacher' approach in Craig's book have been particularly impactful when teaching the low attaining and SEND students and this has been a strength in my recent lesson observations. Although I am an extremely long way from becoming a knowledgeable and experienced teacher of maths, these books have set me off on a journey of discovery and I would recommend that new teachers to the subject as well as 'old hands' will find something to take away and improve current practice.

these books have set me off on a journey of discovery

Plugging the Gaps with Alternative Approaches

In my first year of teaching Maths I was responsible for our Y7 Catch Up Premium Maths group as well as a number of other low attaining Maths classes across KS3 and KS4. As is quite often the case with such classes, many students came under the SEND umbrella. During the first few weeks of the school year I was shocked by the gaps in basic mathematical knowledge that were already present in Year 7 and by the lack of motivation and passion that older students had for the subject.

For me it was clear that trying to build on weak mathematical foundations in Y7 was leading to disengaged students further up the school. Not having a strong understanding of the basic concepts involved in Maths meant that trying to cover existing schemes of learning was slow and at times almost impossible. As a school we needed to change this which is why we signed up to be part of a SEND working group with other schools from around Stoke-on-Trent.

Due to my lack of expertise in the subject I made the first mistake of abandoning the Scheme of Learning. My thoughts behind this was that there was no point in trying to get through our KS3 curriculum when many of the students did not have a strong grasp of basic number skills. After attending the first SEND working group session it was very clear that I had got this wrong and that to better support our SEND students we needed to change this quickly. In trying to support the students to catch up, I realised that what would eventually happen would be that they would be

further behind their peers. I realised that we could not drop the content that needed to be covered across KS3 to focus solely on the knowledge gaps but instead had to find a way of plugging those gaps quickly and in a way that promoted a greater understanding of fundamental mathematical concepts, so that new knowledge could be built on stronger foundations.

In working with Alan Edmiston and the rest of the group I came to realise that our teaching of maths, particularly to our low attaining and SEND students, needed to do the following:

- Provide an alternative 'way in' for students,
- Allow students to explore and talk about maths,
- Focus clearly on the key aspect of learning that you want students to master.

Providing alternative 'ways in' was about introducing key concepts in less typical ways allowing students to develop a concrete understanding of the maths that is being taught as a result of teacher guided discovery. Thanks to my participation in the SEND work group our Y7 Catch Up Premium Scheme of Learning now has key lessons at the start of topics that can be used first as a diagnostic to gauge current understanding and then allow students to develop a much greater and deeper understanding through more abstract teaching and resources. The idea is that these lessons are used to plug the knowledge gaps and consolidate the key concepts so that students are able to move on with the Scheme of Learning.

In line with new expectations around oracy it is also important to build in opportunities for students to explore and talk about maths. This is supported by the initial lessons mentioned above as they are all underpinned by students exploring topics in unusual ways, discussing their findings, making mistakes and working together to find solutions. In doing this I have found that students have not only developed a better understanding, but are also able to talk more confidently about their maths.

The final point is to make sure that the scheme of learning and the teaching allows students to focus clearly on what they need to master. If these lessons are not delivered correctly there is a danger that students remember the wrong thing. Yes, the idea is that the lessons should be fun and engaging, but this shouldn't obscure the maths that we are trying to teach.

Shaping Resilient Mathematicians

As a result of being part of the working group and developing this piece of work, I have already found that the students I work with have developed greater enjoyment when it comes to studying and exploring maths. In addition, students are open to making mistakes and are more driven to work individually and collaboratively to find solutions - they are becoming more resilient mathematicians.

To see these students flourish in maths as a result of this work has been brilliant, and the fact that five out of eleven students from the Y7 Catch Up Premium class graduated at the end of the year gives me the confidence that we have an effective and supportive curriculum for some of our most vulnerable learners.

Daniel Blundell

Bar Modelling as a tool to support learners to visualise the mathematical problems

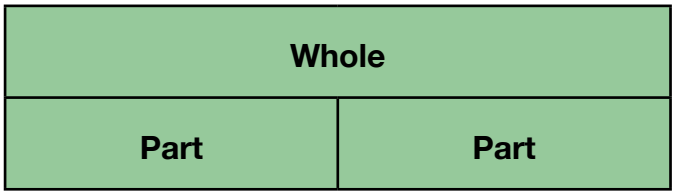
If you were wondering how to use bar modeling then read this article by Louise Needham. She has taken the time to show how this technique can be used from EYFS to GCSE and beyond. This is applicable to all children and so this article could become the focus for some staff CPD or lesson study.

Bar modelling has been around for a number of years, popularised by the Singapore maths teaching methods. Bar modelling allows mathematical problems to be represented pictorially. Pupils that struggle with communicating the mathematics involved are able to communicate much more effectively using this means of representation. The diagrams allow pupils to select the correct mathematical operations before solving the mathematical problems.

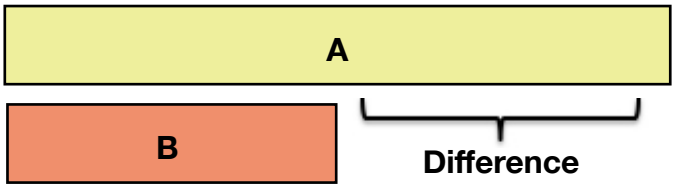
Bar Modelling can be used from EYFS to GCSE. However, pupils need to be shown how and when to use these diagrams so that they are the most effective in solving problems. As Albert Einstein once said “Education is not the learning of facts, but the training of the mind to think.”

There are a number of different types of bar models:

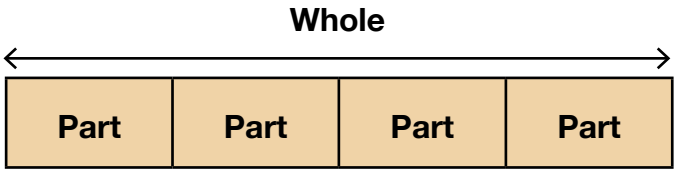
- Part-part-whole model



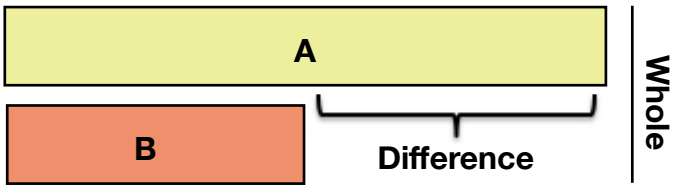
- Comparison model



- Equal parts of the whole



- Part-part-whole and comparison



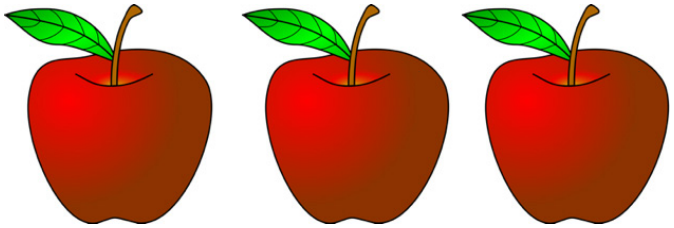
Each type of bar model is more effective for different mathematical problems, and pupils need to shown which bar models to use for different problems and why.

Bar models can be used for a variety of mathematical topics including, algebra, ratio, percentages, fractions, counting, subitising, number bonds, proportion, four operation problems, and many more topics. It is a very versatile tool for pupils, however they must be shown how it can be used to see and eventually solve the problems.

Introducing Bar Modelling at EYFS

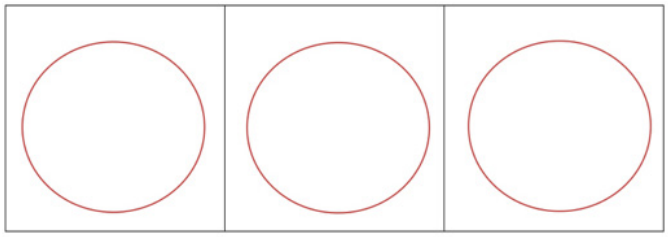
Bar models can be used to introduce counting or subitising in early maths. Note how the steps of each stage slowly introduce more abstract concepts.

Step 1 - Using concrete apples



Step 2 - Using pictorial apples

Step 3 - Using concrete and/or pictorial counters



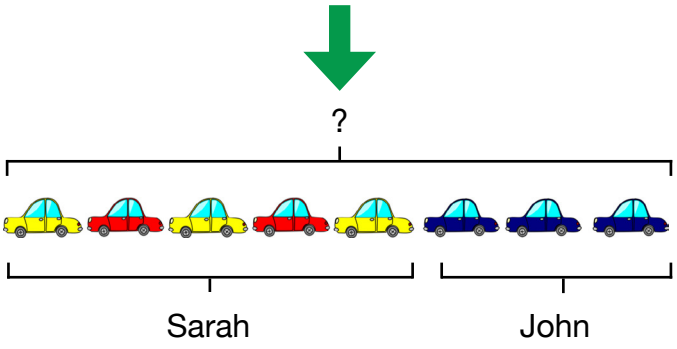
Step 4 - Using concrete and/or pictorial counters and introduce the bar model.

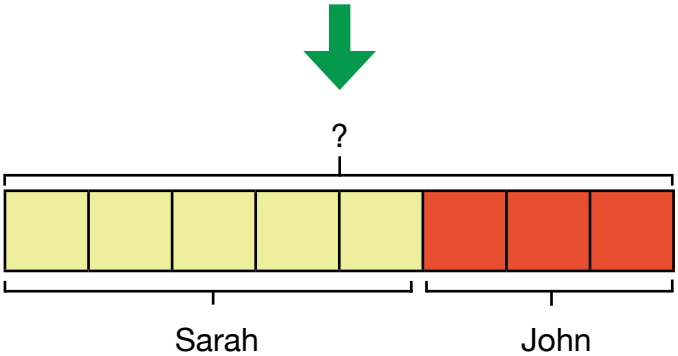
Bar modelling at Key stage 1

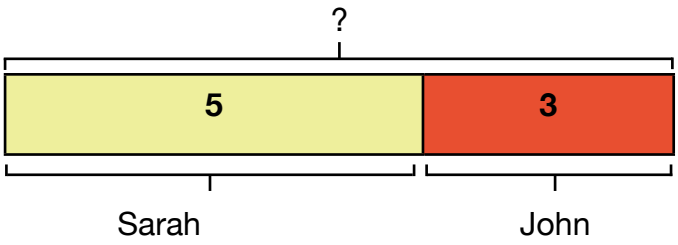
This example of bar modelling is using the part-part-whole model.

Whole	
Part	Part

Sarah has 5 toy cars and John has 3 toy cars. How many toy cars do they have altogether?







5 + 3 =

More examples of bar modelling at Ks1 can be found here:

https://coldfairgreenprimaryschool.org/wp-content/uploads/2018/09/Bar-Modelling-in-KS1.pdf

Bar Modelling at Key stage 2

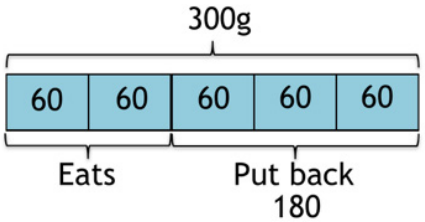
This example of bar modelling is using equal parts of the whole.

Whole

Part	Part	Part	Part

Solve... Matthew has a 300g block of cheese. He eats 2/5 of the cheese and puts the rest back in the fridge. How much cheese did Matthew put back in the fridge?

Model



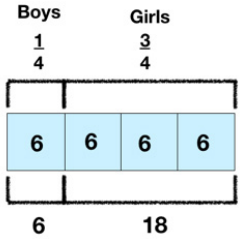
Calculations

300 ÷ 5 = 60

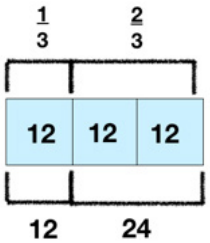
3 x 60 = 180

Here are two more examples with using bar models with fractions of amounts.

$\frac{1}{4}$ of a class are boys.
There are 18 girls.
How many children in the class?



Sal thinks of a number.
$\frac{2}{3}$ of her number is 24.
What was the number she thought of?



More examples of bar modelling at Ks1 and Ks2 can be found here:
https://www.yesatrichmondschool.net/Portals/0/The_Ultimate_Guide_To_Bar_Modelling.pdf

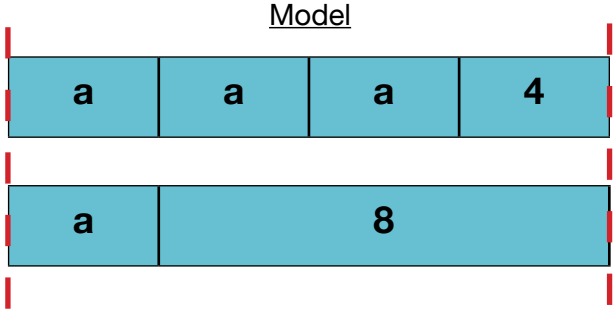
Bar Modelling at Key stage 3

The example below is showing how bar modelling can be used for solving equations, as with the previous examples the calculations of the mathematics involved is also shown along side the bar model. It is essential that this is done so that

pupils can make links between the pictorial and the abstract mathematical concept.

3a + 4 = a + 8

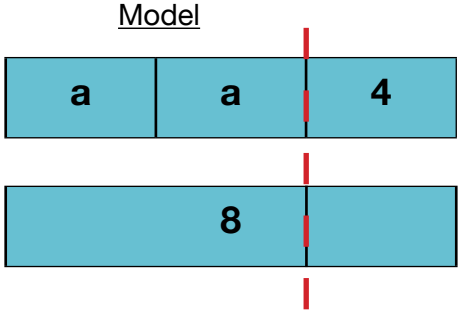
Model



Calculations

3a + 4 = a + 8

Model



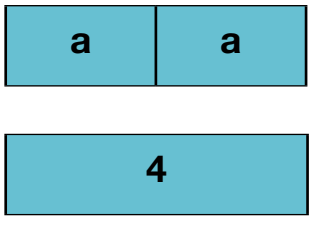
Calculations

3a + 4 = a + 8

-a -a

2a + 4 = 8

Model



Calculations

3a + 4 = a + 8

-a -a

2a + 4 = 8

-4 -4

2a = 4

÷2 ÷2

a = 2

Bar Modelling to solve GCSE questions

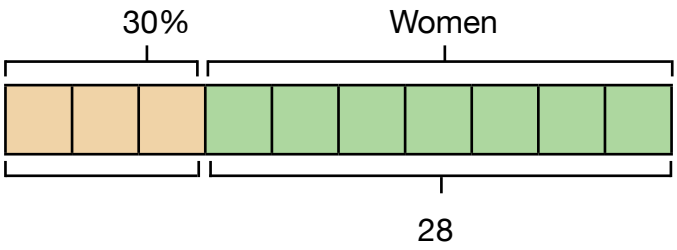
Question taken from Edexcel 1MA1 3F November 2018

There are men and women at a meeting.

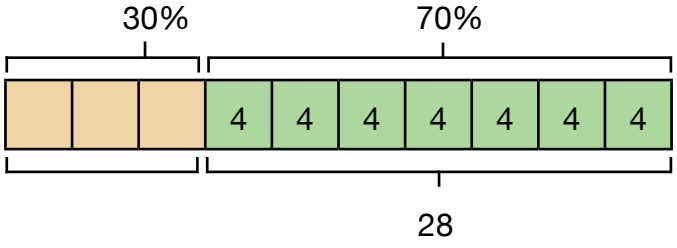
There are 28 women.
30% of the people at the meeting are men.

Work out the total number of people at the meeting.

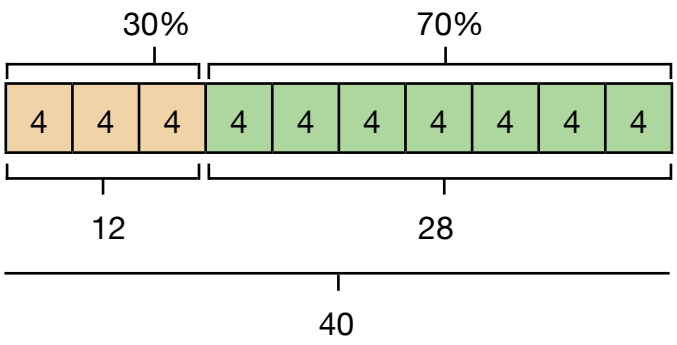
Step 1: Men



Step 2: Men Women



Step 3: Men Women



More examples of bar models at secondary level can be found here:

http://www.greatmathsteachingideas.com/2014/12/26/bar-modelling-a-powerful-visual-approach-for-introducing-number-topics/

For GCSE pupils the benefits of using bar modelling are huge. Pupils that have poor memories and struggle to remember formal methods and procedures have a strategy to use with a number of questions in exam conditions. Pupils are able to use the pictorial method to see 'why' the maths is correct and not just a set of steps to follow, in which they might forget a step in the procedure and then they cannot explain why the maths is correct. For example, in a sharing an amount in a given ratio question, they can see why they have to add the parts and share the given amount between the boxes shown.

Every November White Rose Maths post a bar problem of the day, otherwise known as #Barvember. These problems are a fantastic resource and some of the questions are modelled. Previous #Barvember questions can be found on Twitter and via this link:

https://whiterosemaths.com/resources/classroom-resources/barvember/

Bar Models are an excellent tool for any age or ability in any mathematics classroom. All pupils would benefit from these models, however I would strongly recommend that the class teacher or deliverer to be confident in the use of them first, whether it's practising in the use of them prior to the lesson or focusing on one topic to begin with, otherwise they can create confusion when it is a new way of tackling a mathematics problem.

Louise Needham

The life and times of a nurture group teacher

Alan Edmiston has been involved with St Peter's RC Academy, Middlesbrough for the past two years. Last year he happened to meet Jodie Allonby a specialist nurture group teacher based in KS 3. In this piece Alan interviews Jodie so you can get an insight into her role and the impact this can have on the life chances of the pupils in their care.

I had the good pleasure to interview Jodie about her role at St Peter's and rather than include my questions I will simple share what Jodie said about the life of a nurture group teacher.

My role as a KS 3 nurture group teacher means that I teach one year 7 and 8 class all of their core subjects: English, Maths and Science. I find this very rewarding as I can provide the pastoral support these children need to help them make a success of their secondary schooling. The school is in a very deprived area and so I aim to be a role model for the students to support their socialisation, improve their behavior and to develop with them the strategies they can use to cope with life at secondary school.

Each group spends up to 90% of their time with me although during year 8 we transition to a more standard timetable to allow them to become fully integrated into the life of the school. We use three strands to decide which pupils will join the nurture group: vulnerability, attainment and SEND. We link effectively with our feeder primaries to agree the make up of each class. For example they may identify a child working at Year 3 at the end of KS 2 who may benefit from such a start to KS 3. Often the primaries will comment on how well these pupils do in secondary as they had identified them as those who would not have lasted in mainstream education. We also support the parents who often do not want their children to go into alternative provision but rather stay with their peers throughout their secondary school. The success of this means we are currently thinking of moving this approach into KS4 to support our more vulnerable students.

An interesting part of my role is the sharing of practice with other staff to help the pupils as they move into Year 9 so that they can cope with such a change in structure and routine. A maths teacher and I have a paired teaching timetable throughout Year 8 with to ease the transition.

In maths I find that to support the very specific sensory and processing issues my pupils have, including those on the autistic spectrum, I need to appeal to their senses and make the activities as physical and engaging as possible. I am aware that they see the world very differently and so I try to use as many familiar and real contexts and situations as possible. Although our curriculum is very primary focused, everything starts in the early stages with an engaging stimulus based upon real life contexts that are familiar to the pupils themselves from their own lives. I find this is the best place to start from as I think all learning begins with an action upon an object.

everything starts in the early stages with an engaging stimulus based upon real life contexts

The class respond well to this environment and I think this is due in part to our clear and simple expectations. This environment allows them to make mistakes and to feel safe in the process. They love coming back from other lessons, and its almost as if they feel at home in our class and because of this they can feel safe and begin the long learning journey that lies ahead of them.

Alan Edmiston