Primary
& Early Years
Magazine 74

National Centre
for Excellence in the
Teaching of Mathematics

Welcome to another issue of our Primary Magazine. This magazine has been serving primary teachers for 74 issues with a varied collection of different articles related to maths education and mathematics professional development – all of which are accessible through the Primary Magazine Archive.

Contents

In each issue we have a selection of interesting and useful articles. New National Curriculum in Focus is dedicated to unpicking the new curriculum and how to understand and develop the requirements of the new programmes of study. This edition focuses on a new series of articles exploring how to design learning for column addition.

Where's the Maths in That? shares ideas for ensuring that mathematics is taught and experienced across the curriculum. In the coming months, this series of articles that will explore opportunities for mathematics and mathematical thinking within the new science programme of study. This month the theme is *Forces and Magnets* for Y3.

Finally, Maths in the Staff Room provides simple plans for CPD meetings in your school to be led by a member of staff. These are short meetings that can be used exactly as indicated or adapted to meet the CPD needs of the school. We begin a series focusing in on the features of great teaching in the context of maths which was explored in full in Issue 73. In this issue we explore Dialogic Teaching.

But first, we have a News section, bringing news from the NCETM and beyond to keep you up to date with the fast-changing world of mathematics education.

News

Mastery specialist teachers programme

Details of a new programme, to create 140 new Primary Mathematics Mastery Specialists, will be announced at the end of this month. The two-year programme, run by the NCETM in conjunction with Maths Hubs, is aimed at existing primary teachers, keen to develop their own expertise at teaching for mastery, and also their capacity to pass on their knowledge to groups of other teachers. Details, and an application form, will be published on the NCETM and Maths Hubs websites, but if you'd like to be notified directly, please fill in this form.

Classroom-based research

In Issue 72, Maths in the Staff Room featured the use of models and images to support learning. You may be interested to read this article written by MaST graduate, Sarah Hughes, who shares her experience of supporting learning through play alongside the use of models and manipulatives in her Y2 classroom. She provides evidence for improved learning as a result of the models and manipulatives because the play was purposeful as well as making the models and images more engaging, motivating and meaningful:

> *"The provision of carefully selected models and images triggered curiosity in the children and helped to develop their understanding of number facts as well as other mathematical concepts.*
>
> *"I think it is important to stress at this point, that play, or 'playful teaching', cannot merely be a gesture, it needs to be embedded in a curriculum with context and purpose at the heart".*

New ATM publication

In Issues 68 and 69, National Curriculum in Focus featured problem solving and reasoning in Geometry (KS2). The Association of Teachers of Mathematics (ATM) has recently published a new resource book with ideas for using Geoboards.

Read the editor's review of *Exploring Area and Fractions with Square Geoboards*.

London Mathematical Society CPD Grants

Did you know that the London Mathematics Society (LMS) provides opportunities for schools/ teachers to bid for grants of up to £400 to support teachers with maths-specific CPD? There are certain conditions that need to be met and application deadlines for grants are 31 August, 30 November, 31 January and 30 April each year. These grants are available for all teachers.

NCETM National Curriculum support

Have you explored our National Curriculum Planning Tool yet? This interactive tool will support you in the following ways: your subject knowledge; making connections within and across the primary curriculum; suggest helpful papers, pupil activities, exemplification of expectations, and links to the suite of NCETM videos. There are also sections on the Bar Model, Teaching Fractions, Progression in Reasoning, and Developing a Scheme of Work - all accessible via buttons on the main National Curriculum information page.

Mathematics CPD

Don't forget that if you are looking for high quality providers of maths CPD in the next academic year, use our Professional Development Directory to find CPD Standard Holders (gold rosette) or Accredited Professional Development Leads (purple rosette).

Image credit

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New National Curriculum in Focus

New National Curriculum in Focus is dedicated to unpicking the new curriculum and how to understand and develop the requirements of the new programmes of study for mathematics. You can find previous features in this series here.

Designing learning for column addition

The new curriculum requires children to learn to use standard written methods sooner than has been taught in recent years. In their report Good practice in primary mathematics: evidence from 20 successful schools, Ofsted identified that in the most successful schools pupils were moved to standard written methods swiftly and once pupils were secure with interim methods were moved quickly on to more efficient methods.

What is important is that, if pupils are to be expected to move to a standard written method more quickly than previously expected, we need to ensure that that they do this not only with procedural fluency but with conceptual understanding.

So can this be achieved for the written method of addition?

Let's consider the Y3 statement from the programme of study:

add … numbers with up to three digits, using formal written methods of columnar addition

Before pupils can begin to learn to do this there are a number of skills and concepts that need to have been developed in order to carry out column addition with conceptual understanding:

- Visualise and understand how a three-digit number can be partitioned and recombined into multiples of 100, 10 and 1 with both concrete and abstract representations (i.e. base 10 (concrete) or arrow cards)
- Visualise the relative quantity of the numbers.
- Know the value of a digit because of its position in a number
- Know that addition is commutative
- Be able to say that a three-digit number is greater than *a* but less than *b*
- Be able to mentally add:
    - a three-digit number and ones
    - a three-digit number and tens
    - a three-digit number and hundreds.

Scaffolding learning through procedural and conceptual variation

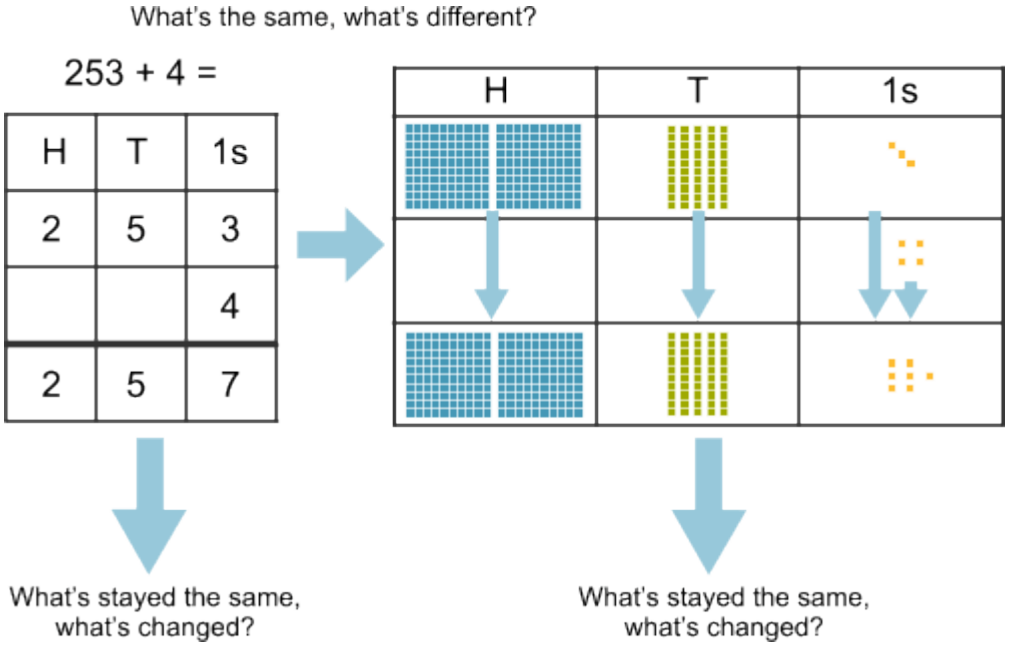
One particular feature of the teaching seen in Shanghai has been the use of teaching with conceptual and procedural variation. Teaching with conceptual variation involves the comparison of static models and images of a mathematical concept which enables pupils to compare by identifying things that are the same and different about the representations which then help to reveal the essential and non-essential features of a mathematical concept. For example multiple examples of different triangles will enable

pupils to generalise that for a shape to be a triangle it has to be a closed shape with three straight sides and three vertices (i.e. the essential features of a triangle). The non-essential features being side length, angle size, and orientation with respect to a horizontal line. Teaching with procedural variation relates directly to Bruner and Wood's ***Scaffolding*** (1976) and involves teaching a mathematical process in such a way that the process is gradually 'unfolded' through a succession of carefully chosen steps so as to gradually enable the child to determine 'what stays the same', and 'what changes' in each successive step. This enables the pupils to identify the variant and invariant features of the process, seeing connections between steps and leads to a generalisation that can be applied to all situations when the process is used.

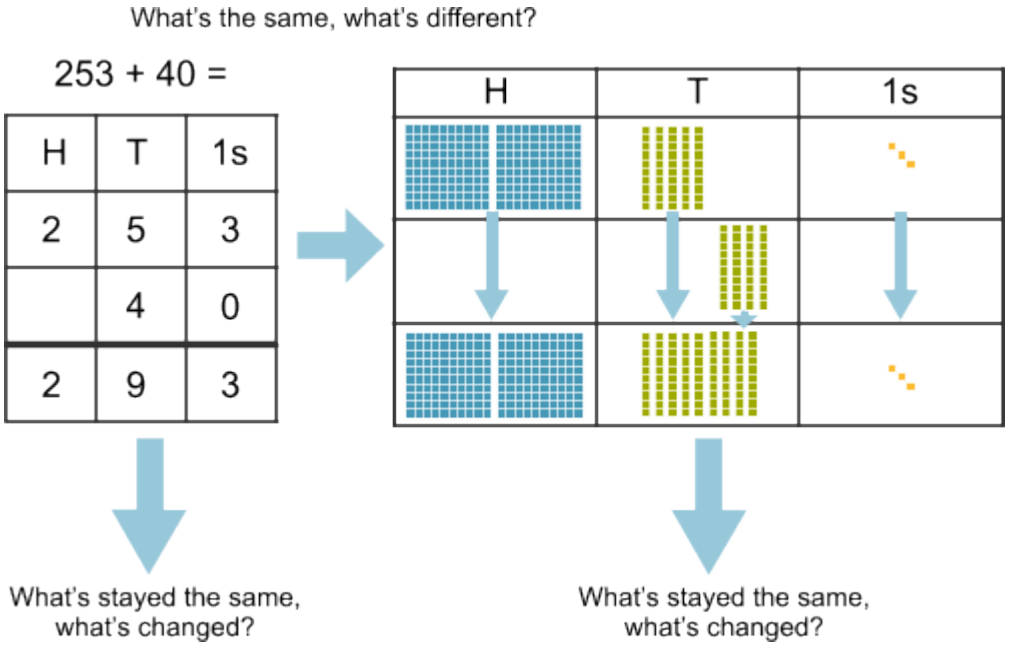
So what might conceptual and procedural variation look like in the context of teaching written addition of three-digit numbers? Written addition involves two distinct processes: adding without regrouping and adding with regrouping. Regrouping occurs when, for example, the sum of the two numbers in the 1s place is greater than 9. We begin without regrouping.

An assumption is made that the key skills and concepts mentioned above have all been acquired by the pupils working on this process.

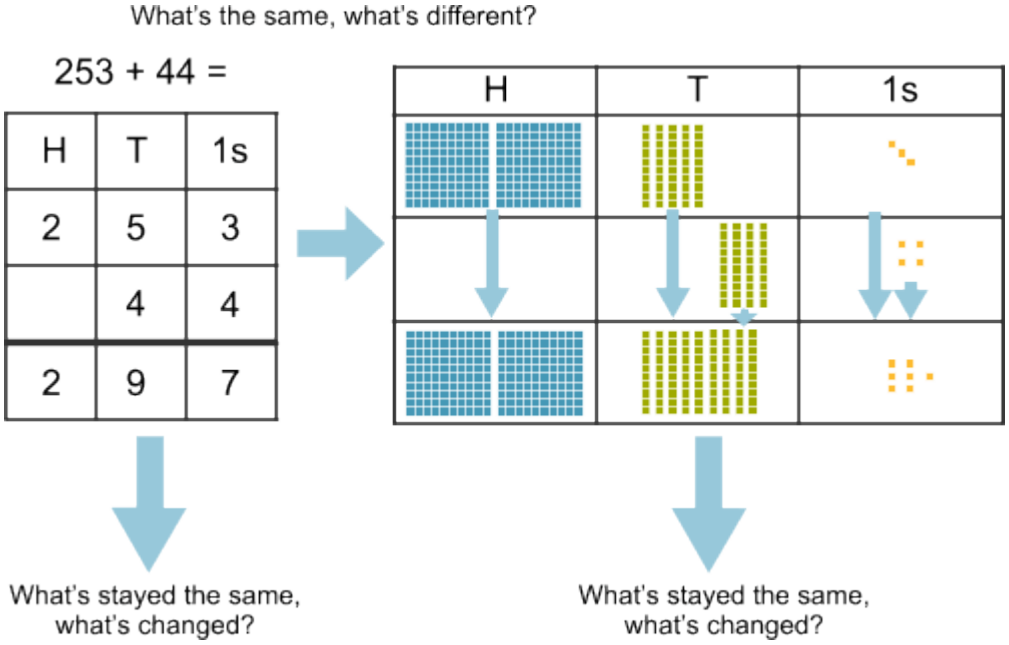
Begin with a simple work problem. Eg. *A sheep farmer has 253 ewes and 4 rams. How many sheep are there altogether?* Write the word problem as an equation/ number sentence, demonstrate the written method using the base 10 resources and use these representations to discuss the same and different features of this problem:



Vary the numbers in the same word problem. Eg. *A sheep farmer has 253 ewes and 40 rams. How many sheep are there altogether?* Use this word problem as before to write the equation/ number sentence, demonstrate the written method with the base 10 resources and use these representations to focus on the similarities and differences of the representations for this problem and the aspects that have and have not changed between this and the previous problem:



Vary the numbers in the same word problem. Eg. *A sheep farmer has 253 ewes and 44 rams. How many sheep are there altogether?* Use this word problem as before to write the equation/ number sentence, demonstrate the written method with the base 10 resources and use these representations to focus on the similarities and differences of the representations for this problem and the aspects that have and have not changed between this and the previous problem:



The variations from left to right draw the pupils' attention to the concrete representation which helps to reinforce the place value of the digits as well as providing an image for the vocabulary when a sentence such as "we add the five tens and four tens".

The variation in successive steps helps to draw the pupils' attention to what changes when ones or tens are added together.

This sequence could then continue with the pupils working with the teacher on a few further successions. Such as:

253 + 45 =
253 + 46 =
253 + 34 =
253 + 24 =

Before pupils work independently on a task such as:

Use the digits 2 5 3 4 1 to make a three-digit number and a two-digit number.
What's the largest total you can make? What's the smallest?

Learning can be deepened by offering further questions such as…

- What's the largest even total you can make? What's the smallest?
- What's the largest odd total you can make? What's the smallest?
- A total nearest to 500? 300? Etc.
- Arrange five digits into a three-digit and two-digit number which sum to a given total.

The examples above are also easily solvable by mental calculation and this could form part of the discussion towards the end of the lesson about how the children might now solve this problem in their head. Some pupils might refer to a number line, counting on or visualising the method taught above.

A subsequent lesson might build on this work by solving similar structured word problems with three-digit and two-digit numbers, adding a three-digit number to more than two two-digit numbers without regrouping or adding two three-digit numbers (without regrouping) using a similar sequence above but with hundreds, tens and 1s.

Addition with regrouping

Use a familiar word problem. Eg. *A sheep farmer has 253 ewes and 6 rams. How many sheep are there altogether?* and continue to use this as the basis for the sequence of problems. Regrouping may take longer to learn conceptually.

The sequence might develop (using the base 10 resources) in this way. 'What's the same and what's different?' and 'What's stayed the same and what's changed?' will, as before, support the successive steps.

Working together with the teacher:

253 + 6 =
253 + 7 = (this problem is a pivot point for introducing the new concept)
253 + 8 =

Working independently:

257 + 2 =
257 + 3 =
257 + 4 =
257 + 5 =
235 + 4 =
235 + 5 =

Using variation for regrouping will enable pupils to observe when regrouping of 1s into tens will need to happen. Sequencing the successive steps carefully will enable pupils to draw a generalisation about the sum of the 1s being greater than nine.

Using conceptual and procedural variation can appear to be slowing down learning but taking time when introducing a new concept or process in this way can develop deep understanding when the concept or procedure is new and thus avoids pupils repeating identical lessons year on year because they haven't understood.

Further resources:

- Primary Magazine Issue 58 Maths to Share: Addition.

You can read more about conceptual and procedural variation here.

Where's the Maths in That? – Maths across the curriculum

*In this section of this Primary Magazine we explore how mathematics can be embedded into other subjects in the context of the new curriculum. The subject in this new series is **science** and over the next few months we will explore the different themes for the KS1 and KS2 science programmes of study and how maths can be embedded in and enhance understanding of scientific ideas. You can find previous features in this series here.*

In this edition we look at the theme of **Forces and Magnets** for Y3 and how a scheme of work for this might incorporate mathematical skills.

The statutory requirements are that children in Y3 are taught to:

- compare how things move on different surfaces
- notice that some forces need contact between two objects, but magnetic forces can act at a distance
- observe how magnets attract or repel each other and attract some materials and not others
- compare and group together a variety of everyday materials on the basis of whether they are attracted to a magnet, and identify some magnetic materials
- describe magnets as having two poles
- predict whether two magnets will attract or repel each other, depending on which poles are facing.

Investigate how far a toy vehicle travels over different surfaces by providing different materials to cover a ramp. Begin by demonstrating the vehicle going down the ramp without any other material on it. Measure how far the vehicle travels to a stop, demonstrating how to record this on a data table. Children should work in groups collecting measurements for each type of test surface e.g. wood, carpet, bubble wrap, felt, foil, corrugated card etc. The same type of vehicle is used with each group and the measurements taken for where it stops from the end of the ramp. With the whole class the data is collected from each group for each material. This data can then be compared. It is likely that the data will not be identical from each group which then makes a useful discussion point about why and also how the data could be used still to draw conclusion about which surfaces are easiest to move along. Ask the children to discuss which measurement should be used to fairly reflect the distance travelled over the different surfaces (this may lead to children 'inventing' a median, although this is not covered in KS2 statistics). Children could either create their own block graph to represent the data they have collected or they could add data to a whole class spreadsheet that will grow as the data is added.

Pupils will need to learn that not all metal objects are attracted to magnets. When testing different materials pupils could be encouraged to sort the materials on a table-top Carroll diagram such as one below. This will enable pupils to see from the diagram that non-metal objects are never attracted to magnets but some metal objects are and some are not.

	Attracted to magnets	Not attracted to magnets
Metal		
Non-metal		

Pupils can design experiments to investigate which magnet in a collection is the strongest. This might involve them counting the number of paper clips or other countable objects that can be picked up by the magnets or they could weigh the amount of paper clips in grams.

Similarly pupils could lay a magnet at the end of a measuring tape on a flat and smooth surface and see how far away a paper clip can be placed from the magnet before it no longer is attracted to it. This could be done with different magnets at the end of the tape.

Another strength test is to see how well the magnet works through different materials by measuring the thickness of the material the magnet is being tested through.

Magnets explain how a compass works. The Earth is a giant compass, which means that any magnetised metal will turn to point its north pole towards the north. You can make one yourself by magnetising an ordinary needle, placing it carefully on a slice of cork, and letting the cork float in a tray of water. Teach pupils how to use a compass to follow directions using other cardinal points such as south, east and west, and intercardinal points such as north-east, south-west etc.

Suggested links:

- National STEM Centre eLibrary: Y3 Forces and Magnets.

Maths in the Staff Room – Short Professional Development Meetings

This section provides suggestions and resources for a professional development meeting for teachers that can be led by the maths subject leader or another person with responsibility for developing mathematics teaching and learning in the school. You can find previous features in this series here.

Dialogic Teaching

In the last issue we provided a meeting to review the effectiveness of teaching mathematics in relation to the two recent reports on effective pedagogy and teaching:

- Exploring Effective Pedagogy in Primary Schools: Evidence from Research
- What Makes Great Teaching?

This meeting follows on from that first reflection and provides a more in depth understanding of how a group of teachers might address any areas of weakness from the audit carried out.

Meeting Aims

- Explore what dialogic teaching means in the context of mathematics.

Timing

- 1.5 hours

Resources

- Slides for Dialogic Teaching and Question Stems
- Video Clip (you will need to log in to the National STEM Centre eLibrary to download this)
- Question Examples Handout.

1.0 Share the aim of the session

From a previous audit of effective maths teaching in the school, you have identified a weakness in the following:

Dialogic teaching is a feature of all maths lessons. Teachers plan for and use **a range of question types** during maths lessons.

1.1 Dialogic Teaching

Share the features of dialogic teaching developed by Robin Alexander, (2008)* using slide 1 and 2.

interactions which encourage students to think, and to think in different ways

questions which invite much more than simple recall

answers which are justified, followed up and built upon rather than merely received

feedback which informs and leads thinking forward as well as encourages

contributions which are extended rather than fragmented

exchanges which chain together into coherent and deepening lines of enquiry

discussion and argumentation which probe and challenge rather than unquestioningly accept

professional engagement with subject matter which liberates classroom discourse from the safe and conventional

classroom organisation, climate and relationships which make all this possible.

Watch clips from this video of a Y5 mathematics class, and ask teachers to identify evidence for some or all of the features of Dialogic Teaching above.

These sections of the video will be particularly helpful to watch:

1:40 - 2:20; 2:51 - 4:44; 5:17 – 7:38; 7:55 – 9.10; 9:40 – 10:40.

Discuss the evidence seen.

(20 mins)

2.0 Questioning

Discuss how you can encourage more meaningful interactions in maths classes by asking the right sorts of questions.

Use slides 3-6 with the teachers responding to exemplify how easy it is to develop mathematics through these questions stems.

Explore how these can be used to develop the features of dialogic teaching in classrooms.

Hand out the supplementary guidance** for including questioning in the maths classroom.

(30 mins)

3.0 Conclusion and Reflection

Consider lessons that will be taught in the next few days and identify some of the questioning stems explored above that could be included in the lessons.

(10 mins)

Further support/resources:

- Dialogic Teaching
- Reasoning Skills for the strands of the new programme of study
- Using Questioning to Stimulate Mathematical Thinking.

*Alexander, R.J. (2008) Towards Dialogic Teaching: rethinking classroom talk (4th edition), Dialogos.

**This material was produced for the Primary National Strategy, which was formally discontinued in 2011. However, the resources have the potential to complement teaching in line with the new 2014 mathematics curriculum).