Primary
& Early Years
Magazine 64

National Centre
for Excellence in the
Teaching of Mathematics

Welcome to a new-look and more compact Primary Magazine. This magazine has been serving primary practitioners for 63 editions with a varied collection of different articles related to maths education and mathematics professional development for primary teachers. We hope you like the new sections - and don't forget that all previous editions of the magazine are accessible through our Primary Magazine Archive.

Contents

In this first edition of the new format 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. In this edition we begin with a focuses on *Algebra in KS1*, exploring what this means in Y1 and Y2 and not just where it is a specific requirement in Y6.

Where's the Maths in That? will share ideas for ensuring that mathematics is taught and experienced across the curriculum. We begin a series of articles that will explore opportunities for mathematics and mathematical thinking within the new science programme of study. The first theme we explore is *Rocks* for Y3.

Finally, Maths in the Staff Room provides a simple plan for CPD meetings in your school to be led by a member of your staff. These are short meetings that can be used exactly as indicated, or adapted to meet the CPD needs of the school. Editable resources are supplied to enable flexibility of 'delivery'. In this edition we focus on *Progression in Reasoning*.

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

Maths Hubs

More than 270 schools across England expressed an interest in taking the lead role in around 30 new, locally-based Maths Hubs across England. The Maths Hubs programme, announced in March 2014 and funded by the DfE, is being coordinated by the NCETM.

Around 80 of the schools, including some primaries, were invited to submit full applications to fill the role, an essential part of which will be to form a collaborative group of partner schools, other institutions and individuals with expertise in maths education - all for the benefit of maths teaching and learning in schools and colleges across a broad geographical area.

The schools chosen for the lead role in each of the hubs are due to be announced in the middle of June.

National Curriculum

Have you explored the National Curriculum Resource and 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.

In addition, we have recently added four new elements to our National Curriculum pages, all closely linked to teaching in line with the new curriculum. They are:

- Teaching Fractions
- The Bar Model
- Progression in Reasoning
- Developing a Scheme of Work.

The DfE have also released the guidance for test item writers for the new 2016 statutory tests. Whilst these are not intended for translation into schools' own assessment systems the KS1 and KS2 frameworks are an interesting read and helpful in unpicking the importance that will be placed on the three aims on the new National Curriculum: fluency, reasoning, and problem solving.

The new 2016+ tests will be structured as follows:

> **End of KS1 Maths will be assessed by statutory test** and teacher assessment.
>
> Paper 1: Arithmetic, max 15 marks, approx. 15 mins
> Paper 2: Mathematical Fluency and Reasoning, max 35 marks, approx. 35 mins.

The resource list for the mathematics test comprises: number line (0–30), hundred square, structured apparatus (tens and ones), pencil, eraser and ruler.

End of KS2 Maths will be assessed by statutory test and teacher assessment.

Paper 1: Arithmetic, max 30 marks, 30 mins
Papers 2 & 3: Mathematical fluency, solving problems and reasoning, max 40 marks per paper, 40 mins per paper.

The resource list for the mathematics tests comprises: pencil/black pen, eraser, ruler (mm and cm), angle measurer/protractor and mirror. Children will not be permitted to use a calculator in any of the components.

Royal Institution Masterclasses

At the recent British Congress in Mathematics Education at Nottingham University in April, Vinay Kathotia from the Royal Institution (Ri) shared an example of one of their mathematics masterclasses using mathematical stories. The Ri, based in London, offers a range of maths masterclasses for school groups as well as a suite of free 'take-away' masterclasses that can be led by a teacher for their pupils in school

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).

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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

Algebra in KS1

Those who are familiar with the new programme of study will have noticed that there is a specific requirement for algebra in Y6. There is a widely held view that in order to work with higher level algebra (i.e. KS3+) pupils need to have had good experiences of algebra in their primary education (Cai et al 2007). Although there is specific content in the Y6 programme of study there is a significant amount of algebra that is hidden amongst the remaining programmes of study for both KS1 and KS2. In this edition and the next we will explore where the hidden algebra from Y1 to Y5 is and provide you with some thoughts about how your scheme of work/ school curriculum might ensure that by the time your pupils reach Y6 algebra is not a daunting new theme to learn in mathematics.

In this issue we focus on Y1 and Y2. Firstly we should explain what is meant by early algebra. Kaput et al (2007) define early algebra as being organised into two 'core aspects' – *Using Symbols to Generalise* and *Acting on Symbols, following rules*. Within these 'core aspects' there are three strands:

1. Generalising from arithmetic and quantitative reasoning
2. Generalising towards the idea of a function
3. Modelling as Language

For simplicity in analysing the KS1 programme of study let us think of these two 'core aspects' as generalising and structuring and restructuring.

Generalising is finding a way to express a relationship from an observed pattern. In KS1 it is not unreasonable for pupils to be able to express mathematical relationships using 'every day' language.

Asking pupils questions such as 'what's the same about…?' or 'what's different about…?' will help pupils to express relationships using every day language.

e.g. What's the same? What's different about these houses?

Young children always find it difficult to describe the differences, often wishing to describe the properties of each object (e.g. "that one has a blue door and the other one has a black door") rather than generalising. Therefore pupils need to be encouraged to use words such as "they both have…" (for same properties) "they each have different…" (for different properties), e.g. "they have different coloured doors".

Structuring and restructuring requires pupils to represent mathematical relationships in different ways. An early example is when children are developing conservation of number and establishing that a fixed number of objects remains the same, irrespective of how they are arranged. i.e. Children are building a structure for a quantity value and seeing what that quantity looks like in different arrangements.

So where can we find examples and opportunities for generalising and structuring and restructuring in the new KS1 programme of study?

This chart (PDF) shows how generalising and structuring and restructuring can be incorporated into the Y1 number strand.

You will notice that some words are emboldened. This is to emphasise the key vocabulary associated with generalising: always, every, only etc. The chart is a guide to the types of generalisations that Y1 pupils should be given the opportunity to generate for themselves as a result of their mathematical activity. Each of these can be supported by the teacher using questions such as "what do you notice?" and "what's the same/ different?". Alternatively you can provide a generalisation to the pupils and ask them whether they think it is **true or false** or **sometimes, always or never** true.

Here are a few further ideas that could also be used in KS1:

- Use the book *One is a Snail Ten is a Crab…* by April Pulley Sayer and Jeff Sayer, to explore how to make different numbers of feet from the creatures in the book *(structuring and restructuring)*
- Use the song *One Finger, One Thumb, Keep Moving* to explore the structure of the number of times each part of the body is sung throughout the song. Use the structure to work out how many times each body part would be sung if another verse were added *(structuring and restructuring)*
- Use a pan balance to explore equivalent number bonds with Numicon or plastic cubes, e.g. 5 + 3 = 7 + 1 (*structuring and restructuring)*

- Use a pan balance with Numicon shapes or plastic cubes to explore missing number problems such as 3 + 4 = □ + 6 (*structuring and restructuring*)
- Encourage pupils to use additive reasoning to solve missing number problems such as:

  12 + 13 = 11 + □
  14 – 3 = 15 - □
  6 – 2 = □ - 3
- Observe whether pupils perform the 'complete' calculations or whether pupils notice relationships between the numbers either side of the equals sign. i.e. "eleven is one less than 12 so the missing number has to be one more than 13". Encourage pupils to observe the relationships by asking questions such as "what do you notice?" and "what's the same, what's different?" Return to the pan balances to support the reasoning
- Use coloured rods to explore generalised arithmetical relationships leading to the use of symbols. Read about how teacher Caroline Ainsworth used this approach with her EYs and Y1 pupils and see examples of her pupils working in this way from an NCETM funded project *(generalising)*
- Use coloured rods to model 'knowns' and 'unknowns' in word problems. Watch these Y2 pupils discussing known and unknown values in word problems in this NCETM video *(structuring and restructuring)*
- Instead of just using the 1-100 or 0-99 square as a tool for calculations, use this resource to draw out generalisations about the structure of the number grid by asking questions such as "what do you notice?" *(generalising)*.

Why not work with colleagues to identify other generalisations that KS1 children should be able to generate from the programmes of study for Y1 and Y2? What about generalisations for shape and measures?

Further links

Research Gateway: Algebra in KS1 and KS2

References

Cai et al, (2005) The Development of Students' Algebraic Thinking in Earlier Grades: A Cross-Cultural Comparative Perspective ZDM 2005 Vol. 37 (1)

Kaput, J., D. Carraher, and M. Banton, (2007) Algebra in the Early Grades, Routledge,
Pully Sayre, A. & Sayre, G., (2003) One is a Crab Ten is a Snail, Walker Books Ltd, London.

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

In this new 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.*

The new programme of study for science suggests that the types of scientific enquiry approaches that pupils will learn "should include: observing over time; pattern seeking; identifying, classifying and grouping; comparative and fair testing (controlled investigations); and researching using secondary sources." (p4).

In each key stage the processes for 'working scientifically' are prescribed as follows:

KS1

- asking simple questions and recognising that they can be answered in different ways
- observing closely, using simple equipment
- performing simple tests
- identifying and classifying
- using their observations and ideas to suggest answers to questions
- gathering and recording data to help in answering questions.

KS2

- asking relevant questions and using different types of scientific enquiries to answer them
- setting up simple practical enquiries, comparative and fair tests
- making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
- gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
- recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
- reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
- using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
- identifying differences, similarities or changes related to simple scientific ideas and processes
- using straightforward scientific evidence to answer questions or to support their findings.

It is clear from these statements that there is much potential to enrich the learning of science and mathematics by integrating, where it is possible, both subjects in the planning and teaching.

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

The statutory requirements for **Rocks** in the Y3 programme of study are:

- compare and group together different kinds of rocks on the basis of their appearance and simple physical properties
- describe in simple terms how fossils are formed when things that have lived are trapped within rock

Below are some ideas for incorporating maths into this science theme

1: Compare and group together different kinds of rocks on the basis of their appearance and simple physical properties

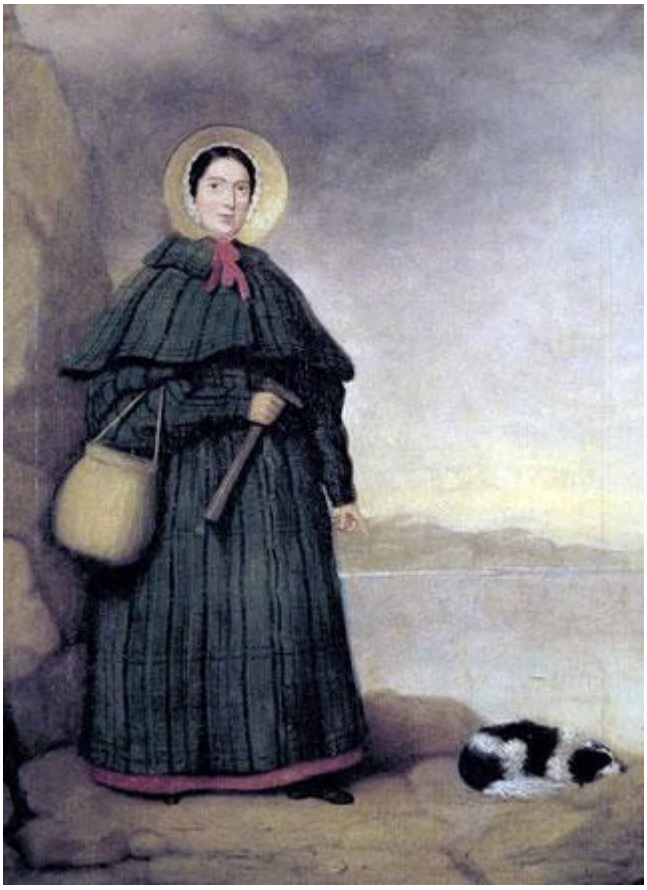
Look at a selection of rocks and find ways to sort them. Say what is the same and what is different about the rocks. Play 'Odd one out' – find a reason why one rock is the odd one out when compared to two other different rocks.

Use a fair test to explore the permeability of different rocks by applying increasingly different amounts of water to the surface of each rock. Record the amounts of water used (**measuring using a syringe**) and record observations on a table.

Sort rocks on a table-top Carroll Diagram e.g. permeable/not permeable against sedimentary/not sedimentary. What conclusions (generalisations) might be drawn from the table?

Get pupils to use their experiments with this BBC online game to create their own Carroll Diagram.

2: Describe in simple terms how fossils are formed when things that have lived are trapped within rock



Learn about Mary Anning and how her fossil discoveries changed scientists understanding of the world millions of years ago. Watch this video clip and then research her life. Plot key events on a timeline from when the fossil was a live animal to present day when the fossils can still be seen in museums and collections.

Compare a selection of fossils by measuring their lengths and masses. Research information about the largest and smallest fossils. Place them on a scale diagram.

Compare the fossil sizes to pupils' own heights. E.g. approximately how many times higher or heavier is the largest ichthyosaur, compared to the pupils?

3: Recognise that soils are made from rocks and organic matter

Separate different soils with different sized sieves. Compare the masses of the different particles collected through each sieve. Add the masses of separated matter to see if it weighs the same as the original soil before sifting. Compare the amounts of each type of matters sieved from each soil type.

You can get further general ideas for teaching this theme from the National STEM Centre National Curriculum pages.

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Soil Samples by OregonDOT (adapted), some rights reserved.

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

Progression in Reasoning

Meeting Aims

- Understand how children's reasoning can develop from Y1 to Y6.

Timing

- 1.5 hours

Resources

- Reasoning cards sheet (cut up into 10 statements)
- Progression Map

Introduction

Share the aim of the professional development meeting.

1. Ask teachers to brainstorm what they understand by 'mathematical reasoning' collect these on a white board or with Post-its on a flipchart

2. Share the 'reasoning' aim of the new National Curriculum

The national curriculum for mathematics aims to ensure that all pupils:

reason mathematically by following a line of enquiry, conjecturing relationships and generalisations, and developing an argument, justification or proof using mathematical language

Compare statements on the whiteboard/ flipchart with the above. What is the same? What's different? (10 mins)

Developing teachers' subject knowledge

3. Provide the set of reasoning cards between small groups of teachers (ideally teachers who teach different ages of children). Ask the teachers to order the statements according to level of sophistication. When most groups have reordered, compare the different lists. Ask the teachers to compare which statements have been placed in the same position and which statements where there is disagreement? Hand out the progression map and compare them with their list of cards. Ask the teachers to reorder their cards in line with the progression map handout. Ask teachers in their small groups to discuss in which year group you might expect to begin to see some children reasoning in each way described

on the cards. Organise their cards to indicate this. Compare and discuss similarities and differences, focusing on the differences to ensure that all are happy that some statements

might be more difficult to assign to a particular year group. Conclude by reminding them that these year group-points are when children are likely to begin to show signs of this level of sophistication but that pupils will spiral around these statements with more sophisticated mathematics as well in the following years. (15 mins)

4. Share evidence for the importance of mathematical reasoning:

Nunes et al (2009)

Mathematical reasoning and knowledge of arithmetic (as assessed in Year 4) made independent contributions to children's achievement in mathematics in KS2 and KS3. While both were important, mathematical reasoning was more important than knowledge of arithmetic for achievement in KS2 and KS3.

Ofsted (2014)

Outstanding achievement of pupils in mathematics (guidance for subject surveys):

*When investigating mathematically, [all] pupils **reason**, generalise and make sense of solutions.*

Ask teachers to reflect as a whole group on how frequently they plan for pupils to reason in their lessons. What form does this reasoning take? (Refer to the progression map cards). (10 mins)

Developing Practice

5. Select and download some practical activities from NRICH: Reasoning and Convincing KS1 and/or Reasoning and Convincing KS2 that the teachers can try out without revealing whether these are KS1 or KS2 activities, identify the reasoning skills by referring to the progression map used earlier and identify the year groups that the tasks could be done with. (30 minutes)

Embedding in Practice

6. Conclude by asking the teachers to discuss how the elements of reasoning can be built in to their daily teaching by referring them to these NCETM National Curriculum progression maps augmented with suggested reasoning activities for each year group and to the NRICH website to support their planning. Use the discussion to move into a short period where teachers reflect on their own learning from the PD meeting by identifying changes in their practice that they think they can make. Take some time to identify some next steps individually and as a school/ year groups in order to ensure that the school has a consistent approach to developing progression in reasoning. (15 mins)

Further links

- Research Gateway: Reasoning
- Professional NCETM Professional Development Calendar: Reasoning.