Introduction

It is a common observation that teaching methods appear to cycle from formal to informal, from didactic teaching to more creative approaches. The new curriculum for maths may seek to emphasise the subject's interconnectedness and creativity but there is an evident focus upon calculation within the primary phase. Establishing such functionality at an early stage provides the necessary tools for children to begin the exploration of number and pattern. This book provides examples of key strategies within calculation.

Mathematics is sometimes thought of as a Marmite subject which children either love or loathe. This is a view echoed within the general population; indeed it seems to be socially acceptable to admit one's inability in maths. I have lost count of how many parents have stated quite candidly during open evenings, 'Oh, I'm just hopeless at maths,' or 'I couldn't do maths at school'. Since no-one has ever made the same admission about reading or writing it must be assumed that maths is a subject in which failure carries little stigma.

Boaler (2009: 95) states: 'The idea that only some children can do well in maths is deeply cultural and it exists in England and the United States. It is also extremely harmful to children's learning and it is something that we need to change. Every child can do as well in maths as they do in other subjects – if they receive good teaching and people believe in them.' It makes sense that we should all have some innate ability in mathematics. Not only are we genetically programmed to identify sensory patterns but the recognition of more and less, and the ability to add and subtract simple numbers, are obvious life skills in any environment. That every child has the capacity to learn mathematics, and ultimately wishes to do so, is a conviction that is as challenging to hold as it is fundamental to successful teaching.

I have taught primary aged school children mathematics for decades but it was teaching on an individual basis that allowed me to realise just what mathematical demons some children carry with them into numeracy lessons. I gained insights into teaching that would have been unavailable within a class setting and duly share these findings below:

Some children will have learned to anticipate failure.

When children have learned to fail in mathematics they will attribute that failure in one of two ways: either maths is stupid or they are stupid. In the latter instance children can be remarkably resilient in retaining the belief despite obvious evidence to the contrary. Pages of their own correct workings are dismissed as irrelevant and they may refuse to participate in any celebration of their achievement. One incorrect answer is seen as irrefutable proof that they can't 'do' maths – 'See? I *told* you I couldn't do it!' Self-diagnosed stupidity becomes a comfortable get-out clause that condones apathy. It is a long road to recovery from this position, so early feelings of success are vital.

Children are good at seeming to cope.

When a teacher is faced with a bewildering array of children in a maths class it is tremendously difficult to identify which child really needs support. Some children ask for help for simple reassurance, some ask for help because it's easier to be helped than to think for oneself, and most do so because they have the wherewithal to understand that asking for help is a proactive part of learning. There are inevitably some children who do not ask for help: they appear to cope and consequently fade surreptitiously into the background. Teachers should not underestimate the sophistication and brilliance of children's coping strategies, certain of which will be to divert attention to others. Just because a child appears competent in an area of maths does not mean that they have any understanding of what they are doing.

Small steps versus big jumps

Steve Chinn (2004: 59) identifies two main types of mathematical thinking and characterises them as grasshoppers and inchworms. Grasshopper students have an apparently intuitive ability to solve problems and present their own solutions, often without recourse to recording. Conversely, inchworm students edge their way towards an answer following set procedures and documenting their progress. Determining a child's thinking style then supporting his strengths and challenging his weaknesses is a vital element within successful teaching. Chinn (2004: 71) also cautions: 'Teachers need to realistically appraise their own thinking style when teaching maths and appraising maths and look at the pupils who sail through their lessons. Then they should look at the pupils who struggle and see if a mismatch of thinking style is a contributory factor.' For many teachers the small steps approach can be tedious even frustrating, but it can offer a lifeline to pupils especially with the recognition that, for some, no step is too small.

Mathematical thinking is a specific skill which can be recognised and taught.

Children can be taught to identify when they are thinking mathematically. They are able to recognise when they are in a mathematical 'zone' and discern when their concentration has lapsed. Teaching metacognition within primary schools may seem challenging but children are oddly comfortable with the idea. Developing an understanding of their own thought processes provides a starting point for the sharing and discussion of ideas and methods.

Talking is essential.

Children need opportunities to share their methods. They can invent the most incredibly convoluted ways of arriving at answers but in doing so they express their personal understanding of mathematics. Teachers may wish to redefine children's ideas for class consumption but must always value the original process.

Successful mathematicians welcome failure.

The most vibrant students enjoy being challenged. Not achieving an answer on the first try becomes a spur to further efforts and increases motivation to ask questions. All children ultimately need to feel that they have succeeded and skilled teaching will provide just enough support to permit the belief that they have discovered a solution by themselves. Challenge and support are the key elements in developing a healthy attitude to maths work.

Rote learning can be positive and rewarding.

The focus on critical thinking, upon children developing an understanding of mathematical processes, has consigned rote learning to becoming a feature of poor teaching and 'unsatisfactory' lessons. Mathematical algorithms are deliberately designed to be easy to implement; they save us time and effort but the mathematics of these algorithms can be considerably more complex than their process. Perversely, we traditionally insist that children should have a critical understanding of the method before the algorithm is taught. It needs to be acknowledged that, in some instances, it is acceptable for children to learn how to perform an algorithm by rote then, in due course, to apply critical thinking to the mechanics of the processes. Zukav (1984: 208) quotes John von Neumann, one of the foremost mathematicians of the 20th Century as saying: 'Young man, in mathematics you don't understand things. You just get used to them.' For some pupils managing their learning in this way feeds success and positive attitudes.

Not all mathematics activities need to have teacher-led challenge and purpose.

Curriculum pressures mean that teachers are obliged to push children forward in their work. Every lesson has a learning objective, success criteria and targets. Where, one wonders, is the opportunity for reinforcement and, more controversially, the opportunity for what might be termed 'Maths-Lite'? Ruth Merttens (1996: 53) suggests that learning mathematics has similarities to learning a language; it is interesting to continue the analogy. When children finish reading a book at school they receive a more challenging text, but at home they may elect to settle down with a familiar book in which the vocabulary is accessible and the outcome already known. Comfort reading, as this is known, is an important aspect of learning as the child gains confidence and pleasure in the process of repetition. It is unlikely for children to engage in formal mathematics at home, thus they are denied similar opportunities for learning. A few easy calculations every once in a while can boost confidence and make mathematics a more friendly subject to those children who might be feeling pressured by the pace of teaching.

Finally, a plea: streaming in primary mathematics is a common strategy to aid differentiation. Effective teachers will keep their groups under constant review. Mathematics is a broad church: children can be outstanding at calculation and utterly confused with data handling or geometry. It is therefore appropriate that differentiation should depend upon the child's ability within the subject matter rather than the group in which they have been placed in an unrelated aspect of maths.

Using this book

Each section within this book begins with Teacher's notes followed by photocopiable activity sheets. The activities are presented within the context of a robot world (the 'Robosphere'), with two introductory sheets establishing this theme as well as making familiar the mathematical symbols and digibot motifs used throughout.

ACTIVITY

The Teacher's notes provide further information about methodology and contextualise activities as necessary.

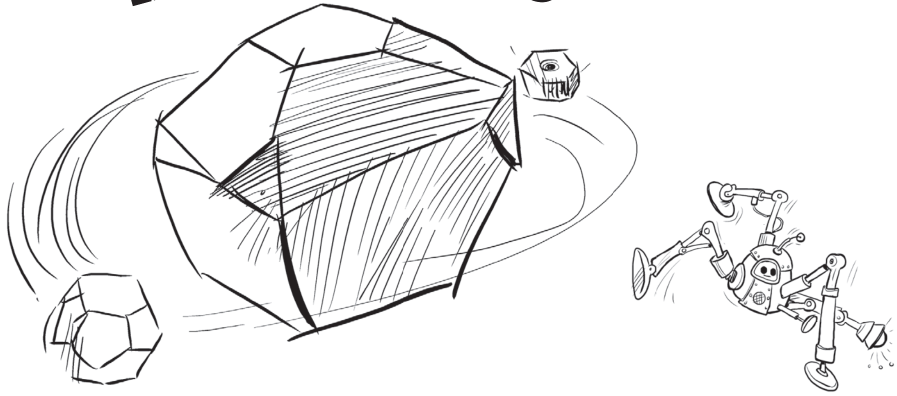
The Activity sheets are described and explained beneath the Teacher's notes and are indicated by the banner as shown on the left.

Resources

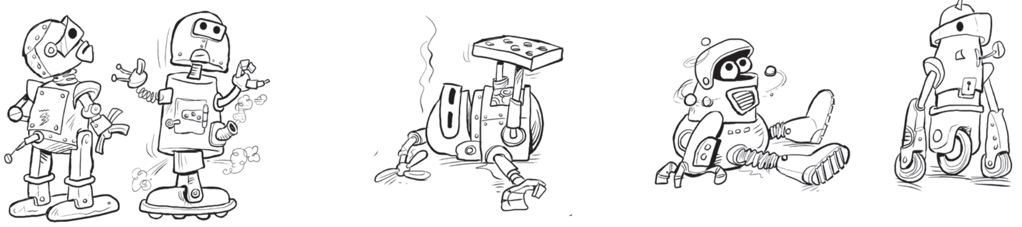
ACTIVITY 01

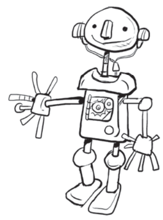
In the far reaches of space an extraordinary world spins slowly around an impossible sun.

This world is the ... **Robosphere**

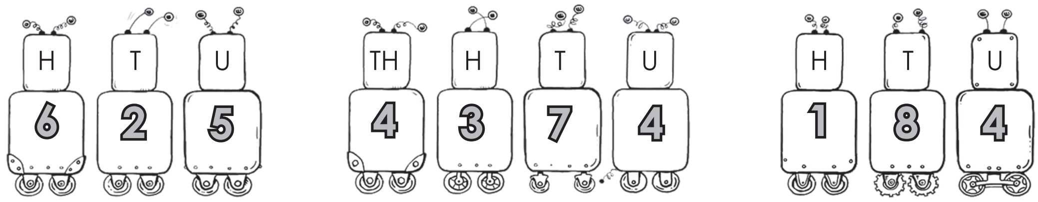


On the Robosphere live lots of tiny robots.

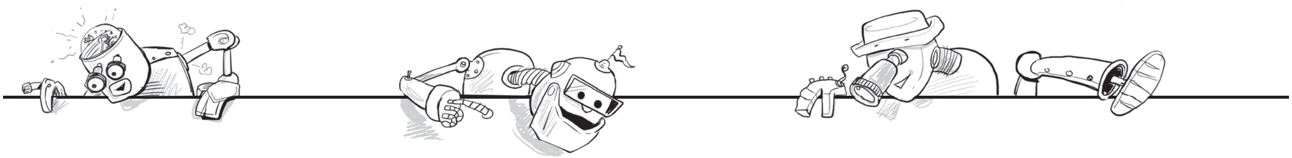




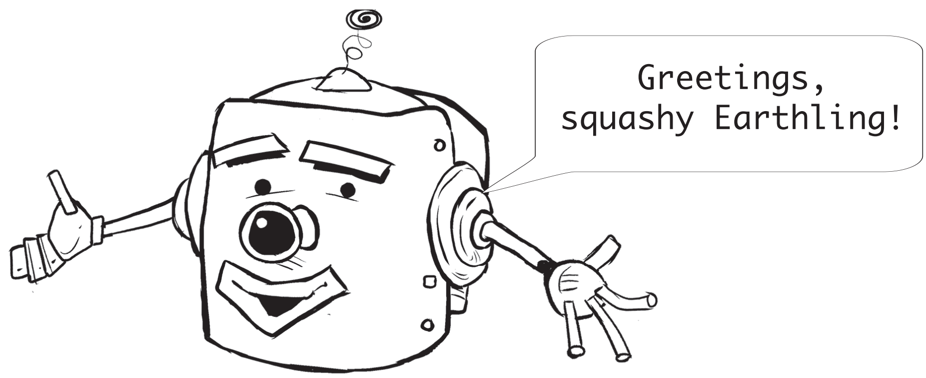
Some of these are called digibots. Digibots clank and jangle themselves together to make numbers.



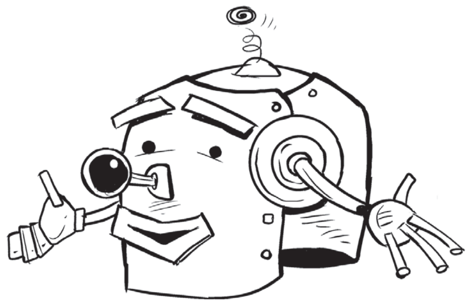
Sometimes you'll see these robots, who point out examples of how calculations have been worked out.



The digibots are controlled by the Big Robot Head, sometimes known just as 'Big Head'.

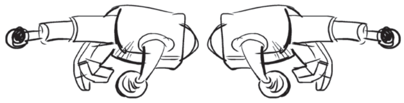


The digibots are controlled by any of these four programs…



ADD

plus + add
altogether +
find the total of

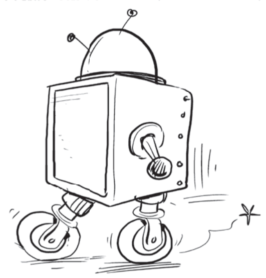


inverse

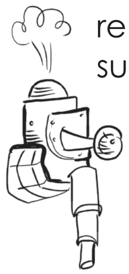
SUBTRACT

take away - minus
find the difference
decrease - reduce

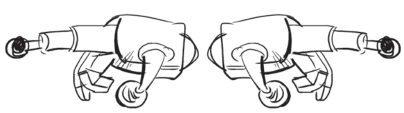
repeated adding



repeated subtracting



MULTIPLY

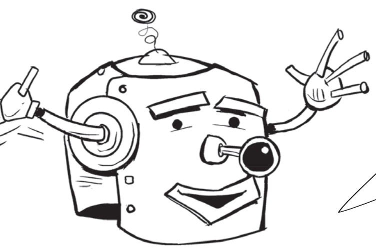


inverse

DIVIDE

times x product x sets of
groups of x lots of

share ÷ equal groups of



‘Equals’ means that the value of the numbers on both sides is the same, like this:

EQUALS

5 + 4 = 9	6 x 2 = 12
or:	
8 = 5 + 3	3 = 12 ÷ 4
or:	
4 + 5 = 3 x 3	2 x 2 = 1 + 3

Place value

Introduction

It is hardly surprising that very young children should spend so much time practising number correspondence. The idea that a single digit can represent multiple objects is an incredibly abstract concept. More startling still is the notion that these digits can change their position and be used to represent other values. Place value, or positional notation, is an advanced concept that defies simple explanation yet young children are happy to accept it as fact. By the time they arrive in years 3 and 4 most children will understand the basics of place value having worked with a range of apparatus that reinforces the concept in some concrete form. However, the Cockroft Report (1982: 87) cautions: 'It should not be assumed that a child who understands the structure of hundreds, tens and units will necessarily be able with ease to make the generalisation to thousands and higher powers of ten. Many children need further practical experience with structural apparatus so that they can work out for themselves the meaning of large numbers and be able to carry out operations with them.' The following activities are merely a formal summary of work that will have been completed using appropriate apparatus.

ACTIVITIES

Number squares
Two number squares are provided; the first is printed conventionally starting with 1 at the top. The second number square, less conventionally but rather more logically, places the smallest numbers at the bottom of the page.

An acetate sheet (or plastic wallet) should be placed over the top of the number squares. Children are then given a whiteboard pen to mark patterns for adding and taking numbers. Moving the acetate sheet will transcribe the pattern to other numbers. Children can be challenged to find patterns which add or take units or multiples of ten. Discuss what happens at the end of rows, e.g. why does 70 + 21 not have the same pattern as 65 + 21?

Number square mash-up
A conventional number square cut into jigsaw sections for children to assemble.

Place value: three digits (1)
An activity sheet for children to practise transcribing from words to numbers within H T U. Children may need to copy their answers onto a separate sheet of paper or workbook, should more space for their handwriting be required. This may apply for all following place value activities.

Place value: three digits (2)
An activity sheet for children to identify place value within a three digit number.

Place value: four digits (1)
Practise transcribing from words to numbers within Th H T U.

Place value: four digits (2)
Identification of place value within a number within Th H T U.

Digibot place value game
Children are each given a game sheet. One at a time, the teacher calls out five digits read from a shuffled pile of ten digit cards. The children write the digits into the digibots with one digit being discarded to the recycling bin. Children should try to make the biggest number possible. They will soon realise that the largest digit must be placed in the highest place value. The game can be varied by aiming to make the smallest number or a target number.

Place value: x 10, x 100, ÷ 10, ÷ 100, followed by place value cards and place value digibots
Begin the activity with the formal activity sheet (Activity 10), reiterating the place values that are incurred through multiplication and division by ten and one hundred. This is shown in the table at the top of the sheet.

The digibot sheet should be photocopied to acetate and used over a place value card. Children can use whiteboard pens to write their calculations onto the acetate and move the digibots across the place value cards to assist in place value calculations.

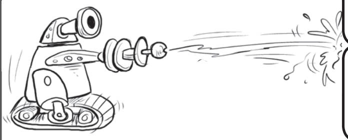
Please note that the place value sheet assumes a 3-digit digibot being used over the larger place value card.

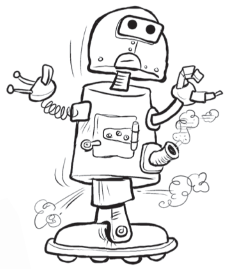
Counting in 50s
Children will quickly associate counting in 50s with counting in 5s; a relationship that is highlighted in this activity sheet.

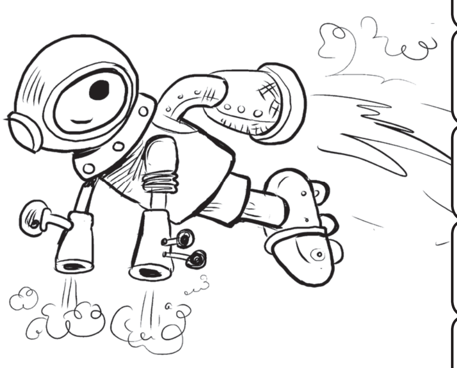
Counting in 25s
Counting in 25s poses more difficulty but children should recognise that the final two digits of each number will be 00, 25, 50 or 75.

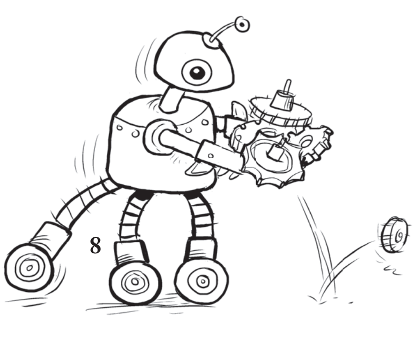
ACTIVITY 03

Number squares









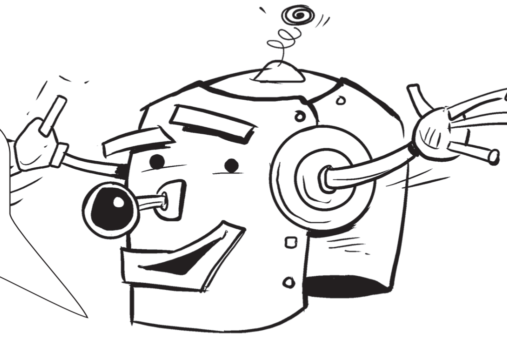
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

91	92	93	94	95	96	97	98	99	100
81	82	83	84	85	86	87	88	89	90
71	72	73	74	75	76	77	78	79	80
61	62	63	64	65	66	67	68	69	70
51	52	53	54	55	56	57	58	59	60
41	42	43	44	45	46	47	48	49	50
31	32	33	34	35	36	37	38	39	40
21	22	23	24	25	26	27	28	29	30
11	12	13	14	15	16	17	18	19	20
1	2	3	4	5	6	7	8	9	10

ACTIVITY 04

Number square mash-up

Well grind my gears! Some little robot has decimated my number square. Can you cut it out and put it back together again?



44 45
54
64 65

1 2
11 12
21 22

57
66 67 68
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84 85 86
94 95 96

31 32
41 42 43
53

73 74 75 76
83

51 52
61 62 63
72

87 88
97 98 99 100

35 36 37
46 47
55 56

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13
23
33 34

38 39 40
48 49 50
58 59 60

9 10
19 20
28 29 30

69 70
78 79 80
89 90

6 7 8
17 18
27

4 5
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24 25 26

71
81 82
91 92 93