The National
Numeracy *Strategy*

Guide for your professional development:

Using ICT to support mathematics in primary schools

Guidance

Curriculum & Standards

Headteachers and Teachers of all primary age pupils

Status: Recommended

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Raising Standards
Standards and Effectiveness Unit

DfEE
Department for Education and Employment

Excellence in schools

Contents

Acknowledgements

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Introduction

Outline of the school-based professional development programme 'Using ICT to support mathematics in primary schools'

One of the big misapprehensions about mathematics that we perpetrate in our classrooms is that the teacher always seems to know the answer to any problem that is discussed. This gives students the idea that there is a book somewhere with all the right answers to all of the interesting questions, and that teachers know those answers. And if one could get hold of the book, one would have everything settled. That's so unlike the true nature of mathematics.
Leon Henkin, 1981

Background

The National Numeracy Strategy is now under way in primary schools. Over the last year a range of professional development materials has been distributed to schools. This pack forms part of that series of INSET resources.

Its purpose is to help a school incorporate ICT (Information and Communication Technology) in the teaching of mathematics. There is a range of ways of using ICT to support mathematics in Key Stages 1 and 2. This pack discusses a number of these ways but focuses particularly on the use of small programs.

Aims

This training pack aims to:

- clarify when, when not, and how to use ICT to support the teaching of mathematics;
- focus the use of ICT in mathematics on objectives from the *Framework for teaching mathematics;*
- suggest useful starting points for teaching;
- show teachers how to use small programs to support their teaching and children's learning of mathematics.

Outline of the professional development materials

The training pack consists of six parts. It is intended that these materials be delivered in school by a key member of staff or an external trainer. Individual units can be revised or revisited using the self-study options within the pack.

The six parts of the pack are:

- Training book – five training and self-study units with OHTs, which are also available as a PowerPoint presentation on CD-ROM;
- Video cassette – video sequences to support the training;
- CD-ROM – software used in the training and illustrated on the video;
- Software user guide – instructions on how to run the software included on the CD-ROM;
- Handling data booklet – eight sample activities, the emphasis being on interpreting data, drawing conclusions and explaining results;
- Sample lessons using ICT – 14 sample lessons for Reception to Year 6 using some of the software from the CD-ROM.

The training book

The training book provides five sessions to support professional development. The longest needs half a day's training; the shortest needs an after-school session of about 80 minutes.

The sessions in the training book are intended mainly for teachers in Reception, Key Stage 1 and Key Stage 2. The sessions are:

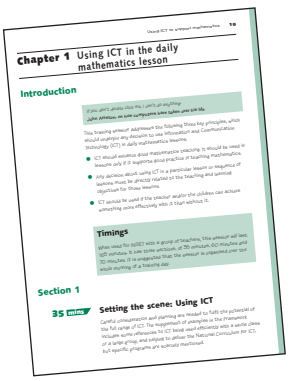
Chapter 1	Using ICT in the daily mathematics lesson	Half a day
Chapter 2	ICT supporting number	Twilight session 1 hr 45 minutes
Chapter 3	ICT supporting handling data	Twilight session 1 hr 20 minutes
Chapter 4	ICT supporting work in shape and space	Twilight session 1 hr 30 minutes
Chapter 5	ICT supporting problem solving	Half day with option Twilight 1 hr 40 minutes without option

Choosing sessions

You should choose the sessions to suit the needs of the staff taken as a whole. Here are some pointers to help you choose:

- Chapter 1 addresses the three key principles which underpin the decision to use ICT in the daily mathematics lesson. It is important to begin with this session.
- Chapter 2 concentrates on developing children's understanding of number, and this should be given priority.
- You may decide to run the sessions in the remaining chapters (3-5) in any order, according to how you have timetabled discussion about mathematics content within your INSET programme.
- In each session there is a range of material from Reception, Key Stage 1 and Key Stage 2.

How to use this book


Chapter 1 Using ICT in the daily mathematics lesson

Introduction

Timings

Section 1

35 mins Setting the scene: Using ICT


What to do [tutor]

What to do [self study]

The training book includes overhead projector transparencies (OHTs) and photocopiable activity sheets (ASs). The OHTs are also provided separately as acetate sheets and the ASs as originals for photocopying. The OHTs are also available as a PowerPoint presentation on CD-ROM.

The member of staff who is leading a session is referred to as the **tutor**. This could be the mathematics co-ordinator, the ICT co-ordinator, another teacher, the headteacher, or someone from outside the school.

Each chapter in the book describes a session, and can be used in two ways:

- The tutor can use the chapter to plan and lead each session for a group of staff.
- Individual teachers or teaching assistants can, if they wish, revise or revisit the chapter at home.

This self-study option makes it possible to provide training for staff who are not able to be present at a school-based session, such as part-time teachers or teaching assistants, regular supply teachers or staff who are absent. It also allows particular staff to study modules that focus on areas of special interest.

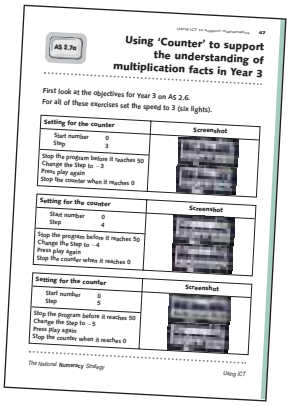
Layout

Each **chapter** in the book works in the same way and contains the same components.

1 An **introduction** that describes the content and the main ideas discussed in the session as a whole.

2 Chapter **sections**, each of which contains:

- Two or three pages of text to read. These pages give all the information required to lead or to study this part of the session. You need to read these pages carefully. If you are the tutor leading other staff, they are the only pages that you need to have in your hand when you are running the session.
- The OHTs and photocopiable activity sheets which are needed for this part of the session. These are presented in the order in which they will be required. An individual using the book for self study will need to read these.



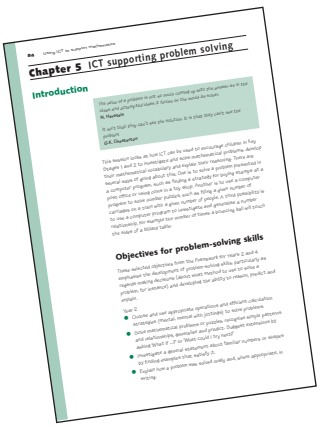
The two or three pages of text at the start of each section are divided into three parts.

Setting the scene

This gives a brief outline of the topics covered in this section of the session.

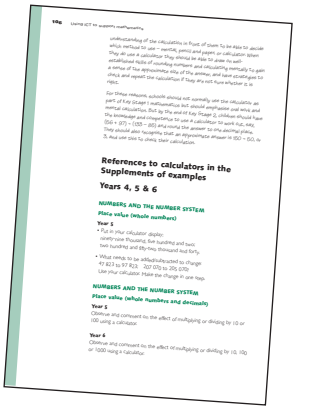
What to do

This includes separate instructions for the tutor who may be leading this part of the session, and for an individual using the book for self study. The instructions include details of when to use a video sequence, OHT or activity sheet. Occasionally there are additional notes for the tutor.



Summary

This gives the key points made in this section. The key points are repeated on the final OHT as well as on this page. The last action in the 'What to do' section for the tutor will be to show this OHT and highlight the key points with everyone in the group. Individuals studying on their own will need to read the summary and reflect on the points made.



The appendices

The training book has six appendices. These are:

Appendix 1	The National Numeracy Strategy *Framework for teaching mathematics from Reception to Year 6* – references to ICT
Appendix 2	The National Numeracy Strategy *Framework for teaching mathematics from Reception to Year 6* – references to calculators
Appendix 3	Using large-screen computer displays in the daily mathematics lesson
Appendix 4	Case study: Developing understanding of decimals in Year 4 using portable ICT equipment
Appendix 5	A list of software included in the training pack
Appendix 6	A list of hardware and software publishers and suppliers referred to in the training pack

Managing the training

A good start to planning your INSET day would be a brief meeting of key staff, such as the headteacher, the mathematics co-ordinator, the ICT co-ordinator, and so on, to discuss:

- which sessions would be most appropriate for your INSET – it should be tailored to your circumstances and you will need to choose carefully from the materials;
- who will take overall responsibility for managing the training, making sure that sessions are planned and resources organised;
- who will lead each session, or part of each session.

Planning your INSET session

Before running an INSET session you will need to:

- read the paragraphs on **Setting the scene** and **What to do** in each chapter;
- study the video sequences, preferably with another colleague, to ascertain how they fit into your training sessions and identify the issues or questions that could arise;

- familiarise yourself with the relevant software programs in advance, and install it on your computer(s);
- set up an OHP, a video recorder, a computer, and a flip chart for the session;
- set up a large screen if possible, or place monitors where the teachers can all see clearly;
- make copies of activity sheets where necessary;
- circulate a programme for the session in advance.

Evaluating your INSET sessions

You will need to evaluate how well the training goes, how useful colleagues find it, and what they would like you to organise next. You could use the evaluation sheet on page 16 or design one of your own.

The video

This training book has an accompanying video. There is a title page before each sequence so that you know when to stop the tape. Floating symbols and numbers indicate breaks between sections of a sequence.

You will need to study the video in advance, preferably with another colleague, to ascertain how the sequences fit into your training sessions and identify the key issues or questions that could arise.

The extracts on the video are examples of how teachers in the schools shown are developing the use of ICT to support their mathematics teaching. They are not intended as examples of 'perfect' teaching, but have been chosen so that their work can be discussed by teachers as part of their own professional development. When you are watching the video, you will be able to consider similarities and differences between the lessons on the video and those in your own school.

There are seven sequences in the video.

Video sequence 1	Chapter 1	**The range of ICT used to support mathematics** Sixteen short extracts of children and teachers from primary schools in Birmingham, Coventry, Worcestershire, Northampton and a nursery school in Sunderland.	8 minutes

Video sequence 2	Chapter 1	**Using ICT effectively** Mary teaches a lesson on place value to her class of 30 Year 1 children in a Northamptonshire school. She uses the 'Numbers' program to support her teaching.	11 minutes
Video sequence 3	Chapter 2	**Using ICT to support number work** Sian uses 'Counter' with her Year 5/6 class of 28 in a Worcestershire school to extend children's knowledge of number and its relation to a number line by counting on in steps of constant size.	11 minutes
Video sequence 4	Chapter 3	**Using ICT to support handling data** Sheila, Iris, Elaine and Bob from a Northamptonshire school and Sally and Paul from a Worcestershire school work on handling-data skills with groups of children in Years 2 to 6.	12 minutes
Video sequence 5	Chapter 4	**Using ICT to support shape and space** Becky works with her class of 30 Year 1 children in a Worcestershire school to develop the language associated with distance, direction and turn. The work is further developed with a small group using a floor robot.	13 minutes
Video sequence 6	Chapter 5	**Using ICT to support problem-solving (1)** Karen uses 'Toy Shop' with her Year 2 class of 36 children in a Coventry school. She demonstrates the idea of using coins to pay for a toy, then explains to a group how to use the program and that to win the toy they have to pay the last coin.	13 minutes

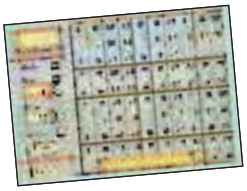
Video sequence 7	Chapter 5	**Using ICT to support problem-solving (2)** Ann-Marie is introducing her class of 30 Year 4 children in a Coventry school to the 'Play Train' program. She works with the whole class, demonstrating the idea of filling carriages with passengers using restricted numbers. You also see how the work done away from and at the computer complement each other.	11 minutes

We are very grateful to all the teachers and children of the schools that featured in this video. They are:

School	LEA	No. on roll	FSM*
Brambleside Community Primary School	Northamptonshire	183	1%
Bugbrooke Community Primary School	Northamptonshire	317	3%
Holy Family RC Primary School	Coventry	465	12%
Houghton Community Nursery School	Sunderland	80	–
Lyppard Grange Primary School	Worcestershire	254	1%
Mount Nod Primary School	Coventry	276	4%
St Peter's CE Junior School	Birmingham	180	14%

*Children eligible for free school meals.

The CD-ROM

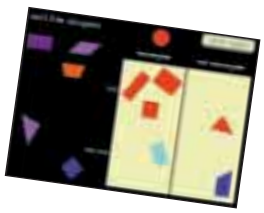


The CD-ROM contains:

A Six short programs:

- Counter
- Play Train
- Minimax
- Monty
- Take Part
- Toy Shop

These are conversions from programs originally developed by the Association of Teachers of Mathematics (ATM), the Microelectronics Education Programme (MEP) and SMILE Mathematics.

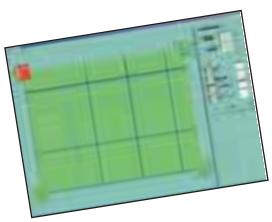


B Seven Internet applications or films:

- Handy Graph
- What's My Angle?
- Function Machine
- Carroll Diagram
- Venn Diagram
- Sorting 2D Shapes
- Unit the Robot

The programs in section A and B are written in JAVA or FLASH and will operate on either Apple or PC platforms.

These programs will operate on these Internet browsers: Microsoft Internet Explorer version 3.0 or later or Netscape Navigator version 3.0 or later.



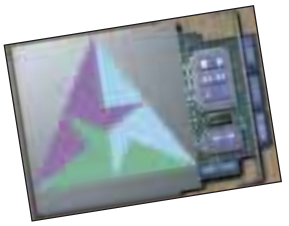
C Four other programs:

- Bounce (an MEP program re-versioned by Micros and Primary Education (MAPE))
- Strawberry Garden (a program extracted from the Thomas the Clown suite published by Longman Logotron)
- Multiple Machine (a program extracted from the Number Works suite published by Sherston Software)

- VersaTile (a time-limited version, 10 minutes use per session, of the program published by Longman Logotron).

These programs will operate only on PC platforms.

The programs and the training material



This table shows where the programs on the CD-ROM fit in with the training materials.

Program	Training chapter	Video sequence	Sample lessons	Platform
Counter	Chapter 2	1, 3	1, 2, 3	PC, Apple
Play Train	Chapter 5	7	4, 5	PC, Apple
Minimax	Chapter 1		6, 7	PC, Apple
Monty			8, 9	PC, Apple
Take Part			10, 11	PC, Apple
Toy Shop	Chapter 5	6	12, 13	PC, Apple
Handy Graph		4		PC, Apple*
What's My Angle?				PC, Apple*
Function Machine				PC, Apple*
Carroll Diagram				PC, Apple*
Venn Diagram		4		PC, Apple*
Sorting 2D Shapes		1, 4		PC, Apple*
Unit the Robot	Chapter 4			PC, Apple*
Bounce	Chapter 5			PC only
Strawberry Garden	Chapter 4			PC only
Multiple Machine	Chapter 2			PC only
VersaTile	Chapter 4			PC only

* These programs require the FLASH plug-in to run.

Software user guide

This booklet provides running guides for the programs listed in A and B above. The programs in C have on-screen help.

Handling data booklet

This booklet contains a series of eight sample activities for teachers in Key Stages 1 and 2, showing the types of activity and progression outlined in the handling data strand of the NNS *Framework for teaching mathematics from Reception to Year 6*. They have been adapted for teachers' use.

Sample lessons using ICT

This book contains descriptions of fourteen lessons where ICT is used in primary schools to support mathematics. Each lesson has the appropriate objectives from the NNS *Framework for teaching mathematics Reception to Year 6*. Thirteen of these lessons use short programs and the fourteenth uses 'Easiteach' with an interactive whiteboard.

The National **Numeracy** Strategy INSET Session(s)

The session(s) was/were useful because ...

Session title	Grade very good ⟷ poor	Comments
	1 2 3 4 5	
	1 2 3 4 5	
	1 2 3 4 5	
	1 2 3 4 5	

Please give your suggestions for further sessions you would like us to run for you …

Chapter 1 Using ICT in the daily mathematics lesson

Introduction

If you don't double click me, I can't do anything.

John Aniston, on how computers have taken over his life

This training session addresses the following three key principles, which should underpin any decision to use Information and Communication Technology (ICT) in daily mathematics lessons.

- ICT should enhance good mathematics teaching. It should be used in lessons only if it supports good practice in teaching mathematics.
- Any decision about using ICT in a particular lesson or sequence of lessons must be directly related to the teaching and learning objectives for those lessons.
- ICT should be used if the teacher and/or the children can achieve something more effectively with it than without it.

Timings

When used for INSET with a group of teachers, this session will last 165 minutes. It has three sections, of 35 minutes, 60 minutes and 70 minutes. It is suggested that the session is organised over the whole morning of a training day.

Section 1

35 mins

Setting the scene: Using ICT

Careful consideration and planning are needed to fulfil the potential of the full range of ICT. The supplement of examples in the *Framework* includes some references to ICT being used efficiently with a whole class or a large group, and helping to deliver the National Curriculum for ICT, but specific programs are scarcely mentioned.

What to do [tutor]

- Display OHT 1.1, then show video sequence 1. 10 mins
  Explain that this sequence contains 16 clips that show the range of ICT that can be used to support the teaching and learning of mathematics.
- Display OHTs 1.2a and 1.2b, which list the different uses 10 mins
  of ICT shown in the video sequence. Give out copies of AS 1.3. Ask groups of three or four to write notes on different sections (allocated by you) of the video and to discuss how the use of ICT supported the teaching and learning of mathematics.
- Take feedback from a number of groups using OHT 1.3 5 mins
  (same as AS 1.3) as a prompt.
- Ask everyone to consider what they have seen and how 5 mins
  it relates to their own practice. What things would they feel happy to try?
- Look at sample lessons 6 and 7 ('Minimax') and 14 5 mins
  ('Easiteach' with an interactive whiteboard) and discuss in the light of the previous discussion.

What to do [self study]

Look at OHT 1.1, then watch video sequence 1, with 16 clips of classrooms where a range of ICT is being used as part of the daily mathematics lessons.

Look at OHTs 1.2a and 1.2b, which list the different uses of ICT seen in the sequence, then – using AS 1.3 as a guide – make notes in your notebook about how you saw the ICT supporting the teaching and learning of mathematics.

Consider what you have seen and how it relates to your own existing practice. Are there some things that you would feel happy to try? Look at sample lessons 6 and 7 ('Minimax') and 14 ('Easiteach' with an interactive whiteboard).

Summary

- A wide range of ICT can support the teaching and learning of mathematics.
- Careful consideration and planning is required to get the best out of the full range of ICT available.
- Examples within the *Framework* include some references to ICT being managed efficiently by a teacher working with a whole class or a large group.
- Seeing teachers using ICT can encourage others to reflect on their own practice.

Tutor's notes

Video sequence 1 shows teachers and children from primary schools in Birmingham, Coventry, Worcestershire, Northampton, and a nursery school in Sunderland, using ICT to support their mathematics teaching and learning. The 16 clips in the sequence are listed below.

1 Digital camera: Children in Year 4 are taking pictures to exemplify 'pattern and shape' in the environment in and around the school grounds. Later they look in detail at one of the images in close-up using a graphics package.

2 Floor robot: The teacher works with a group of six year 1 children with a 'Roamer' floor robot. She sets the children the challenge of working out a series of instructions to move the robot along a path, modifying them in the light of the robot's response.

3 CD-ROM encyclopaedia: A group of children in Year 6 use *Hutchinson's Encyclopaedia* to search for the ten highest mountains in the world, then discuss how the table of results is presented.

4 Pocket calculators: The teacher works with her Year 6 class using calculators to support the teaching of decimals and fractions.

5 Audio cassette tape: The teacher recaps work on the 3 times table with a group of Year 3 children and then provides a pre-taped audio cassette tape of a 'times-table rap' for them to listen to, using headphones plugged into a tape recorder.

6 Using a computer program: The teacher uses the 'Numbers' program with her Year 1 class to provide electronic images to help children develop their understanding of place value.

7 Television broadcast: A class of Year 4 and 5 children watch one of the BBC's 'MegaMaths' programmes, reinforcing the recall of multiplication facts.

8 The Internet: A group of children in Year 6 log on to the Teletext website for up-to-date weather information. They then record the average, maximum and minimum daily temperatures and the weather forecasts for their home city, Birmingham, and Chicago, a holiday destination for one of the children, and compare the two sets of data.

9 Interactive whiteboard: A teacher with a class of Year 3 children uses RM's 'Easiteach' linked to an electronic whiteboard to demonstrate the pattern of the numbers containing the digit 8 using first a dynamic 1–100 grid, then a 101–200 grid.

10 Video camera: A video camera has been set up to record data of birds visiting a bird table over a period of time. The teacher then plays back the video and the children use tally sheets, then a block graph, to represent the data gathered.

11 Using a 'binary tree' computer program: The teacher uses 'Flexitree' with a group to sort a set of numbers.

12 Sensors attached to a computer: A Year 5 class has set up sensors connected to a computer to measure changes in ambient light and temperature over 12 hours. The teacher asks the children to look at the data in graph form and suggest explanations for any changes, encouraging them to look for and explain connections between the changes in the different sets of data.

13 Flash movie: The teacher works with a group of six children at the computer using the 'Sorting 2D Shapes' Flash program to discuss properties of shape. The children use the computer to help them sort shapes.

14 OHP calculator: The teacher works with her Year 6 class and uses an OHP calculator to support the teaching of decimals and fractions.

15 Audio cassette recorder: Children in a nursery class use an audio cassette recorder to listen to the 'Five Speckled Frogs' song.

16 Using a computer program: The teacher uses 'Counter' with her whole class to develop the children's understanding of triangular numbers.

ICT as a support to teaching and learning

ICT includes calculators as well as computers, and extends to the whole range of audio-visual aids, including audio tape, video film and educational broadcasts.

The whole range of ICT can be used in various ways to meet two important goals in the teaching of mathematics:

- **to support your teaching;**
- **to motivate children's learning.**

Uses of ICT in the video

- Taking pictures of shapes with a digital camera
- Using a floor robot to move along a path
- Researching data from a CD-ROM encyclopaedia
- Using pocket calculators for fractions and decimals
- Listening to audio tapes for learning counting and multiplication facts
- Using computer programs for number with a large screen monitor and a projector
- Using a 'binary tree' computer program to sort a set of numbers

Uses of ICT in the video (continued)

- Watching a television broadcast about multiplication
- Collecting data from the Internet about the weather
- Using an electronic whiteboard to demonstrate number patterns
- Using a video camera to record birds visiting a bird table
- Using a sensor attached to the computer to gather data over a period of time
- Using a computer film to explore shapes
- Using an overhead calculator for fractions and decimals

OHT & AS 1.3

What you saw

Mathematics learned

ICT used

How used
Whole class
Large group
Small group
Individual

How mathematics teaching was enhanced

Section 2

60 mins

Setting the scene: Choosing and using suitable ICT resources

Teachers should be able to choose and use the most suitable and most effective resources, including ICT, to meet their teaching objectives.

What to do [tutor]

- Ask everyone to look at the section 'Information and communication technology (ICT)' on pages 31-32 in the Introduction to the *Framework*, which highlights how computer programs can be used to support teaching mathematics. — 5 mins
- Display OHT 1.4, which gives a summary of the six bullet points on page 31 of the *Framework*. Now show video sequence 1 again. Ask the participants to work in pairs and identify which of the 16 clips they saw related to each of the six points. — 25 mins
- Take feedback from two or three pairs on how they categorised the clips. — 15 mins
- Now display OHT 1.5, and discuss the questions posed on it with the group. — 10 mins
- Look at sample lessons 8 and 9, using 'Monty' to explore the 100 square. How does this reflect on what has been shown in this section? — 5 mins

Tutor's notes

Some of the clips in video sequence 1 could be linked to the following examples listed on page 31 of the Introduction to the Framework.

explore, describe and explain number patterns	Clip 16, using the 'Counter' program
practise and consolidate number skills	Clip 6, using the 'Numbers' program

● explore and explain patterns in data	Clip 3, using a CD-ROM encyclopaedia Clip 12, using sensors to measure, display and explain trends in light and temperature
● estimate and compare measures of length or distance, angle, time and so on	Clip 2, using a floor robot
● experiment with and discuss properties of patterns in shape and space	Clip 1, using a digital camera Clip 13, using a Flash movie
● develop their mathematical vocabulary, logical thinking and problem-solving skills	Clip 11, using a 'binary tree' program and many of the clips

What to do [self study]

Look at OHT 1.4, then read pages 31–32 in the Introduction to the *Framework*, which highlights how computer programs can be used to support teaching mathematics.

Watch video sequence 1 again. How do the 16 clips it contains relate to the six bullet points in the *Framework*? Look at OHT 1.5 and consider the questions.

Look at Appendix 1, References to ICT in the *Framework for teaching mathematics Reception to Year 6*. Choose an example relevant to the age group you are teaching and plan how you would develop this as part of a daily mathematics lesson. Look at sample lessons 8 and 9, using 'Monty' to explore the 100 square. How does this reflect on what you have learned in this section?

Make a record of the session in your notebook.

Summary

- Teachers should be able to choose and use the most suitable ICT resources to meet their teaching objectives.

- Using ICT in a daily mathematics lesson can help children to:
  - explore, describe and explain number patterns;
  - practise and consolidate number skills;
  - explore and explain patterns in data;
  - estimate and compare various measures;
  - experiment with shape and patterns;
  - develop mathematical vocabulary, logical thinking and problem-solving skills.
- ICT is particularly effective when used by a teacher to demonstrate particular mathematical concepts and ideas.

Using ICT in a daily mathematics lesson

The right ICT resources can help teaching and learning mathematics in several ways, including:

- **exploring, describing and explaining number patterns;**
- **practising and consolidating number skills;**
- **exploring patterns in data;**
- **estimating and comparing measures of distance, angle, time, and so on;**
- **experimenting with properties of shapes and geometric patterns;**
- **developing mathematical vocabulary, logical thinking and problem-solving skills.**

The value of ICT in supporting mathematics

- What were the good teaching points you saw in the extracts?
- What extra value, if any, did ICT provide to support mathematics?
- What are the implications for the development of your own ICT skills?

Section 3

70 mins

Setting the scene: The teacher's role

The teacher's role in mathematics is to demonstrate, explain and question, to stimulate children's interests, invite predictions and interpretations of what is displayed and ask individual children to respond.

If the display is big enough, ICT can be used effectively to teach a whole class. Otherwise it can be used with a group of children or one or two children working independently.

When children are working in a group or individually, the teacher should intervene from time to time to develop the children's learning and to make sure they are all participating.

ICT can be used to support direct teaching or children's independent work. It is also appropriate to use ICT as part of the plenary session of the lesson to enable the teacher or children to explain their work.

What to do [tutor]

Before you start, set up a computer and connect it to a large-screen monitor, television set or projector. Insert the *Using ICT to support mathematics: Programs CD-ROM* into the computer drive and load 'Minimax'. Set up the program to include subtraction, THTU, and making the maximum number.

- Begin by displaying OHT 1.6, then show video sequence 2, a lesson taught by Mary from Northampton who is demonstrating place value both with and without the use of ICT. 15 mins
- Ask groups of three or four to consider the points raised on OHT 1.6 and how they were reflected in the video lesson. Take feedback from no more than two groups. 10 mins
- Demonstrate the program 'Minimax', and involve the group by asking questions and getting contributions. 15 mins
- Ask groups of two or three to plan how 'Minimax' might be used with a whole class, a group or pairs of children as part of a daily mathematics lesson. Take feedback, recording the key points. 15 mins
- With the whole group, discuss the resource implications for using ICT in daily lessons. Show OHT 1.7 to summarise the session. 15 mins

What to do [self study]

Set up the computer. Insert *Using ICT to support mathematics: Programs CD-ROM* and load 'Minimax'. Set up the program to include subtraction, THTU, and making the maximum number. Run the program 'Minimax' and play the game.

Look at OHT 1.6, then watch video sequence 2, featuring a lesson taught by Mary from Northampton. She is demonstrating place value both with and without the use of ICT. Think about how the points on the OHT match the practice seen in the video, and how 'Minimax' might be used with a whole class, group or pairs of children as part of the daily mathematics lesson. Make a record in your notebook.

Now consider the implications for resourcing ICT in the daily lesson. Look at the Summary on OHT 1.7 and make notes in your notebook.

Summary

- The teacher's role in mathematics is to demonstrate, explain and question, to stimulate children's interests, invite predictions and interpretations of what is displayed and ask individual children to respond.
- ICT can be used effectively by the teacher with the whole class, a group, or one or two children working independently.
- When children are working in groups or individually the teacher should intervene occasionally to develop the children's learning and to make sure they are all participating.
- Teachers should organise ICT resources effectively to meet the mathematics learning objectives.

Organising classroom ICT resources

Teachers should organise ICT resources effectively to meet the mathematics learning objectives. This could include:

- **using ICT with the whole class or a group to introduce or review a topic;**
- **organising individuals, pairs or groups working with ICT to ensure that each participant is engaged, intervening when appropriate, and reports on what they have learned;**
- **positioning resources for ease of use and minimal distraction, while paying due regard to health and safety;**
- **ensuring that work done using ICT is integrated with other work, so that it supports the teaching of mathematics.**

Summary

- The teacher's role in mathematics is to demonstrate, explain and question, to stimulate children's interests, invite predictions and interpretations of what is displayed and ask individual children to respond.

- ICT can be used effectively by the teacher with the whole class, a group, or one or two children working independently.

- When children are working in groups or individually, the teacher should intervene occasionally to develop the children's learning and to make sure they are all participating.

- Teachers should organise ICT resources effectively to meet the mathematics learning objectives.

Chapter 2 ICT supporting number

Introduction

When you can measure what you are talking about and express it in numbers, you know something about it.
Lord Kelvin

In mathematics, if a pattern occurs, we can go on to ask, why does it occur? What does it signify? And we can find answers to these questions. In fact, for every pattern that appears, a mathematician feels he ought to know why it appears.
W.W. Sawyer

This session looks at how ICT can be used to support children's developing understanding of number by exploring, describing and explaining number patterns. ICT is helpful in supporting the development of number as it provides an opportunity to enhance good teaching and can offer a means of demonstrating ideas about number that cannot be done in any other way. Children can discuss and interpret what is shown on the screen, they can predict what will happen next, and they can try out ideas and see what happens. ICT provides instant feedback that is not available in other ways. Examples of this include watching a counting meter with sequences of numbers shown slowly one at a time, and experimenting with patterns of numbers highlighted on a number grid.

Children should be given the chance to undertake a wide range of activities involving looking for and describing number patterns. They should also be able to extend number sequences such as 4, 8, 12, 16, or 2, 7, 12, 17, 22, and explain what is happening. By identifying these number sequences, children learn the building blocks for multiplication and division facts.

Objectives concerning number patterns and sequences are highlighted in each year of the *Framework for teaching mathematics*. In Year 1, for example, children are asked to describe and extend number sequences, to count on and back in ones from any small number, and in tens from and back to zero. They should also count on in twos from zero, then one, and begin to recognise odd and even numbers as 'every other number', as well as count in steps of 5 from zero to 20 or more, then back again, and begin to count from zero in steps of 3.

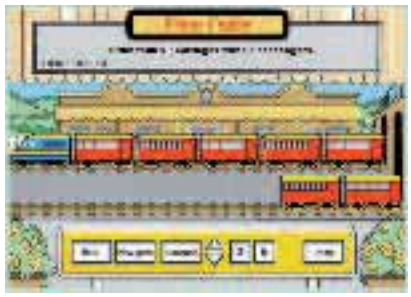
In Year 5, children are expected to recognise and extend number sequences formed by counting from any number in steps of constant size, extending beyond zero when counting back; to make general statements about odd and even numbers, including the outcome of sums and differences, to recognise squares of numbers to at least 10 × 10, and to know by heart multiplication facts up to 10 × 10.

Several simple programs support the development of number facts and operations and looking for number sequences and patterns. Screenshots from a selection of them are shown below. The full value of these programs is best seen as a teacher demonstration tool, where different examples can be readily explored and feedback provided.

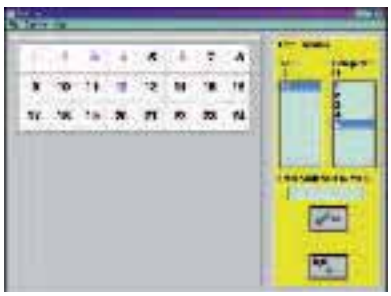
Complements: Developing Number ATM

Counter
Using ICT to support mathematics: Programs CD-ROM

Monty
Using ICT to support mathematics: Programs CD-ROM



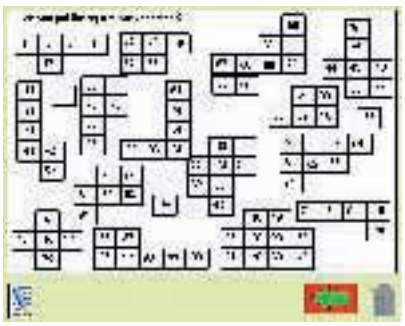
Play Train
Using ICT to support mathematics: Programs CD-ROM



Factor
SMILE

Multiples
SMILE

Numbers: Steps, Maths Factory, Harper Collins



Adventures on a 100 square: My World of Maths from 7-11
Semerc/Granada Learning

Timings

When used for INSET with a group of teachers, this session will last 105 minutes. It is in two sections, the first of 45 minutes and the second of 60 minutes. There are two options you can choose for Section 2. Both take 60 minutes.

Section 1

45 mins

Setting the scene: Number sequences

There are many ways of developing work on number sequences with children, using, for example, large number lines, counting sticks or number grids. Typical activities include calling out the next number in a sequence, showing a number card to represent a missing number, or counting back from a given number. There is a range of ICT resources that can support these activities. Programs such as 'Counter', which is demonstrated in this section, provide a useful stimulus for children's understanding of the number system.

What to do [tutor]

- Display OHT 2.1. Ask everyone to work in pairs and to focus on either Year 1 or Year 5. They should draw up a list showing how they might teach one of the objectives shown on the OHT. If needed, suggest they look at the Supplement of Examples for ideas of starting points. After 6 minutes, take feedback, discussing any points of interest that arise. 8 mins
- Show video sequence 3, which shows Sian working with a Year 5/6 class of 28 children in a school in Worcestershire. She is using the 'Counter' program to extend children's 12 mins

knowledge and understanding of number through demonstration, explanation, questioning and the stimulation of discussion. She focuses on counting on or back from any number in steps of constant size.

- Display OHT 2.2. Divide the group into threes or fours to discuss the questions on it. Take feedback from the groups. 10 mins
- Ask everyone how what they have seen relates to their own current practice. Are there some things they would feel happy to try? Display OHT 2.3 to summarise this section. 10 mins
- Finish by looking at sample lessons 1, 2 and 3, using 'Counter' to count on and show number sequences. 5 mins

What to do [self study]

Read the 'Setting the scene' section. Look at OHT 2.1 and decide whether to focus on Year 1 or Year 5. Look at the relevant Supplement of Examples in the *Framework* for ideas for starting points. Draw up a list showing how you might teach one or two of the objectives.

Look at OHT 2.2 and watch video sequence 3 of the teacher in Year 6 using 'Counter' to extend children's knowledge and understanding of number through demonstration, explanation, questioning and stimulating discussion. Jot down your thoughts on the lesson in your notebook.

Consider how what you have seen relates to your own existing practice. Are there some things that you would feel happy to try? Look at the summary on OHT 2.3, considering each point carefully and making notes in your notebook. Finish by looking at sample lessons 1, 2 and 3, using 'Counter' to count on and show sequences.

Summary

- There are several ways for teachers to introduce and consolidate number sequences with children.
- ICT is effective when used by the teacher to demonstrate particular mathematical concepts and ideas.
- The teacher supports the demonstration with clear explanations and well-targeted questioning. This can stimulate pupil discussion and invite predictions and interpretation of what is displayed.

Number sequences – objectives

Year 1

- Describe and extend number sequences.
- Count on and back in ones from any small number, and in tens from and back to zero.
- Count in twos from zero, then one, and begin to recognise odd and even numbers as 'every other number'.
- Count in steps of 5 from zero to 20 or more, then back again; begin to count in steps of 3 from zero.

Year 5

- Recognise and extend number sequences formed by counting in steps of constant size.
- Make general statements about odd and even numbers.
- Recognise squares of numbers to at least 10×10.
- Know by heart multiplication facts to at least 10×10.

Teaching aspects of number

- What key aspects of number does the teacher focus on in this lesson?

- How did the teacher …
  – demonstrate?
  – explain and question?
  – stimulate discussion?
  – invite predictions and interpretations?

- What are the children showing they understand through their responses to the teacher's questioning?

- What does ICT contribute that helps the teaching to be more effective?

Summary

- There are several ways for teachers to introduce and consolidate number sequences with children.
- ICT is effective when used by the teacher to demonstrate particular mathematical concepts and ideas.
- The teacher supports the demonstration with clear explanations and well-targeted questioning. This can stimulate children's discussion and invite predictions and interpretation of what is displayed.

Section 2

60 mins

ICT in teaching and learning multiplication and division facts

There are two options for this session. Both are timed to last 60 minutes.

What to do [tutor]

OPTION 1

- Display OHT 2.4. Ask everyone to work in pairs and discuss how they would introduce work on one of the objectives on the OHT for Year 2 or Year 4, bearing in mind what they would expect a Year 1 or Year 3 child to have been taught and how they would develop that knowledge. — 10 mins
- Take feedback from a few pairs, discussing any points of interest that arise. — 5 mins
- Using a computer connected to a large-screen monitor, television or projector, demonstrate 'Multiple Machine', set at Level 1 (5 or 10). Ask the group what is happening on the screen. Practice several examples until the teachers are familiar with how the program operates. — 20 mins
- Ask the teachers to work in small groups to consider how they could use this program with their whole class or with a group. After 10 minutes, take feedback from the groups, discussing any points that arise. — 15 mins
- Summarise the section using OHT 2.5, emphasising that ICT should only be used if it supports good practice in teaching mathematics, and finish by asking everyone to consider what they would feel happy to try with their class. — 10 mins

OPTION 2

- Display OHT 2.4. Ask everyone to work in pairs and discuss how they would introduce work on one of the objectives on the OHT for Year 2 or Year 4, bearing in mind what they would expect a Year 1 or Year 3 child to have been taught and how they would develop that knowledge. — 10 mins
- Take feedback from a few pairs, discussing any points of interest that arise. — 5 mins
- Ask everyone to look at AS 2.6, listing objectives concerning multiples and multiplication facts for Years 3 to 6. — 5 mins
- Demonstrate 'Counter', using a computer connected to a large-screen monitor, television or projector. Set up a single counter starting at 27 with a step value of 3. Click the start button. After it has run for a short while, ask the group what is happening to the number in the counter. Do another example, such as a start number of 84 and a step value of –4. Click the start button, let it run for a short while, then ask the group what is happening this time. — 10 mins
- Ask the teachers to work in twos or threes and to select one of the activity sheets, AS 2.7a, 2.7b, 2.7c or 2.7d, which deal with teaching objectives from years 3 to 6 respectively. Ask everyone to try out the 'Counter' program, which should be loaded beforehand. The teachers should set the counter(s) as shown on the activity sheet, run them for a short while and discuss what is happening each time. — 20 mins
- Ask pairs of teachers to consider how this program could be useful in teaching the objectives listed on AS 2.6 for Years 3, 4, 5 and 6. Take feedback. — 5 mins
- Summarise the session using OHT 2.5, emphasising that ICT should only be used if it supports good practice in teaching mathematics. — 5 mins

What to do [self study]

Look at OHT 2.4. Imagine you are a teacher working in Year 2 or Year 4, and consider how you would introduce work on one of the objectives shown on the OHT. Consider what you would expect a Year 1 or a Year 3

child to have been taught and how you would develop that previous knowledge. Make notes in your notebook.

Follow either of the following two options.

OPTION 1

Set up the computer. Load 'Multiple Machine' from the CD-ROM. Run the program and consider what is happening on the screen. Practice several examples until you are familiar with how the program operates.

Consider how you could use this program with your whole class or with a group, bearing in mind that ICT should only be used if it supports good practice in teaching mathematics. Make notes in your notebook and think about what you would be happy to try with your own class.

OPTION 2

Look at AS 2.6, which lists objectives concerning multiples and multiplication facts for Years 3 to 6. Set up the computer. Load 'Counter' from the CD-ROM. Set up a single counter starting at 27 and a step value of 3, and click the start button. What is happening to the number in the counter? Do another example, such as a start number of 84 and step value of -4. Let it run for a short while, and think about what is happening this time.

Select one of the activity sheets, AS 2.7a, 2.7b, 2.7c or 2.7d, which deal with objectives from Years 3 to 6 respectively. Set the counter(s) as shown on the activity sheet, run the program for a short while and make notes on what is happening each time.

Consider how this program could be useful in teaching the objectives listed on AS 2.6 for Years 3, 4, 5 and 6, bearing in mind that ICT should only be used if it supports good practice in teaching mathematics. Make notes in your notebook.

Summary

- There are several ways in which teachers can introduce and consolidate multiplication and division facts and doubles and halves with young children.
- Familiarity with what is available in ICT can support the effective teaching and learning of particular mathematical concepts and ideas.
- Teachers need to consider how they can integrate the use of ICT in their whole-class teaching or group work in the daily mathematics lesson.

Objectives concerning multiplication and division facts

Year 2

- Know simple multiplication and division facts by heart.
- Derive doubles and halves quickly.

Year 4

- Recognise multiples of 2, 3, 4, 5 and 10, up to the tenth multiple.
- Understand the principles – though not the names – of the commutative, associative and distributive laws as they apply to multiplication.
- Know by heart facts for the 2, 3, 4, 5 and 10 times tables.

Summary

- There are several ways in which teachers can introduce and consolidate multiplication and division facts and doubles and halves with young children.

- Familiarity with what is available in ICT can support the effective teaching and learning of particular mathematical concepts and ideas.

- Teachers need to consider how they can integrate the use of ICT in their whole-class teaching or group work in the daily mathematics lesson.

Multiples and multiplication facts – objectives

Year 3

- Describe and extend number sequences. Count on and back in tens or hundreds, starting from any two- or three-digit number. Count on and back in twos starting from any two-digit number, and recognise odd and even numbers to at least 100. Count on in steps of 3, 4 or 5 from any small number to at least 50, and then back again.
- Recognise two-digit and three-digit multiples of 2, 5 or 10 and three-digit multiples of 50 and 100.
- Know by heart facts for the 2, 5 and 10 times tables. Begin to know the 3 and 4 times tables.

Year 4

- Recognise multiples of 2, 3, 4, 5 and 10, up to the tenth multiple.
- Understand the principles (not the names) of the commutative, associative and the distributive laws as they apply to multiplication.
- Know by heart facts for the 2, 3, 4, 5 and 10 times tables.

Year 5

- Recognise squares of numbers to at least 10 $\times$ 10.
- Know by heart multiplication facts up to 10 $\times$ 10.

Year 6

- Recognise squares of numbers to at least 12 $\times$ 12.
- Consolidate knowing by heart multiplication facts up to 10 $\times$ 10.

AS 2.7a

Using 'Counter' to support the understanding of multiplication facts in Year 3

First look at the objectives for Year 3 on AS 2.6.

For all of these exercises set the speed to 3 (six lights).

Setting for the counter	Screenshot
Start number 0 Step 3	
Stop the program before it reaches 50 Change the Step to −3 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 4	
Stop the program before it reaches 50 Change the Step to −4 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 5	
Stop the program before it reaches 50 Change the Step to −5 Press play again Stop the counter when it reaches 0	

AS 2.7a

Continued

Setting for the counter	Screenshot
Start number 0 Step 10 Stop the program before it reaches 100 Change the Step to −10 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 1 Step 2 Stop the program before it reaches 100 Change the Step to −2 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 2 Stop the program before it reaches 100 Change the Step to −2 Press play again Stop the counter when it reaches 0	

AS 2.7b

Using 'Counter' to support the understanding of multiplication facts in Year 4

First look at the objectives for Year 4 on AS 2.6.

For all of these exercises set the speed to 3 (six lights).

Setting for the counter	Screenshot
Start number 0 Step 2	
Stop the program before it reaches 100 Change the Step to −2 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 3	
Stop the program before it reaches 100 Change the Step to −3 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 4	
Stop the program before it reaches 100 Change the Step to −4 Press play again Stop the counter when it reaches 0	

AS 2.7b

Continued

Setting for the counter	Screenshot
Start number 0 Step 5 Stop the program before it reaches 100 Change the Step to −5 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 10 Stop the program before it reaches 100 Change the Step to −10 Press play again Stop the counter when it reaches 0	

AS 2.7c

Using 'Counter' to support the understanding of multiplication facts in Year 5

First look at the objectives for Year 5 on AS 2.6.

For all of these exercises set the speed to 3 (six lights).

Setting for the counter	Screenshot
Start number 0 Step 2	
Stop the program before it reaches 100 Change the Step to −2 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 3	
Stop the program before it reaches 100 Change the Step to −3 Press play again Stop the counter when it reaches 0	

Work out the counter settings required for the other multiplication tables up to 10 × 10.

AS 2.7c

Continued

Select two counters. Choose a horizontal or vertical setting for the counters.

Setting for the counter	Screenshot
Counter one Start number 1 Step 1	
Counter two Start number 1 Step 3 Step increment 2	
Press play Stop the counter when it reaches 100	

Explain what the two counters are showing.

Use the same settings again, but this time press the step button rather than play.

AS 2.7d

Using 'Counter' to support the understanding of multiplication facts in Year 6

First look at the objectives for Year 6 on AS 2.6.

For all of these exercises set the speed to 3 (six lights).

Setting for the counter	Screenshot
Start number 0 Step 2	
Stop the program before it reaches 100 Change the Step to −2 Press play again Stop the counter when it reaches 0	

Setting for the counter	Screenshot
Start number 0 Step 3	
Stop the program before it reaches 100 Change the Step to −3 Press play again Stop the counter when it reaches 0	

Work out the counter settings required for the other multiplication tables up to 10 × 10.

AS 2.7d

Continued

Setting for the counter	Screenshot
Counter one Start number 1 Step 1	
Counter two Start number 1 Step 3 Step increment 2	
Press play Stop the counter when it reaches 100	

Explain what the two counters are showing.

Use the same settings again, but this time press the step button rather than play.

Chapter 3 ICT supporting handling data

Introduction

Errors using inadequate data are much less than those using no data at all.
Charles Babbage

The purpose of models is not to fit the data, but to sharpen the questions.
Samuel Karlin

This session explains ways that ICT can be used to support children in Key Stages 1 and 2 in sorting, classifying and representing data they have collected or had supplied to them ready-made.

Children's ability to handle data effectively involves them in sorting, classifying, making decisions about what facts are important and how best to organise, store and present them, and then in interpreting their findings. Computers can, for example, be used to access, display and interpret sets of data, display a bar chart or pictogram showing the outcome of a class vote or generate a conversion graph.

Children need to be given opportunities to explore a range of ways of representing data so they can decide which is best for displaying their results, and ICT allows them to explore and test their hypotheses. Computers enable teachers and children to test 'What would happen if ...?' type statements, to make changes and see the effect of those changes instantly. This encourages a positive attitude to 'error making' and to the trial and refinement method.

Handling-data objectives

This sample of objectives from the *Framework* for Years 2 to 5 highlights the progression in handling-data skills.

Year 2

- Solve a given problem by sorting, classifying and organising information in simple ways, such as: in a list or simple table, in a pictogram or in a block graph. Discuss and explain results.

Year 3

- Solve a given problem by organising and interpreting numerical data in simple lists, tables or graphs, including simple frequency tables; a pictogram with a symbol representing two units; bar charts with labelled intervals in ones, then twos; and Venn and Carroll diagrams (one criterion).

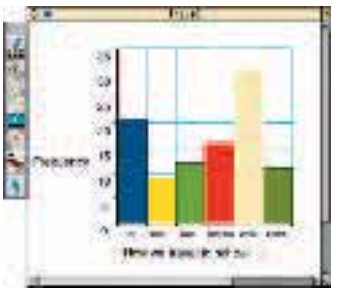
Year 4

- Solve a problem by collecting quickly, organising, representing and interpreting data in tables, charts, graphs and diagrams, including tally charts and frequency tables; pictograms with a symbol representing 2, 5, 10 or 20 units; bar charts with intervals labelled in 2s, 5s, 10s or 20s; and Venn and Carroll diagrams (two criteria).

Year 5

- Solve a problem by representing and interpreting data in tables, charts, graphs and diagrams including bar line charts with the vertical axis labelled in 2s, 5s, 10s, 20s or 100s, first where intermediate points have no meaning (e.g. scores on a dice rolled 50 times), then where they may have meaning (e.g. room temperature over time).
- Find the mode of a set of data.

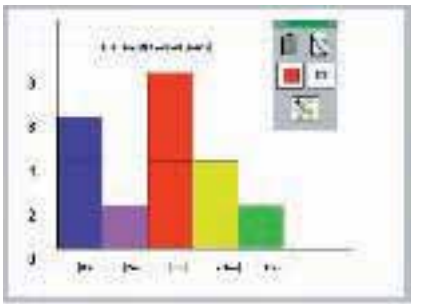
This is a range of programs to support the development of handling-data skills.



Junior Pinpoint
Longman Logotron

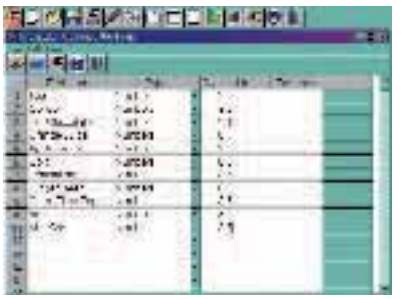
Picturepoint
Longman Logotron

Starting Graph
RM



Bar chart: My World
Semerc/Granada Learning

FlexiTree
Flexible Software



Information Workshop
Black Cat Software

DataSweet
Kudlian

Decision trees: Steps Maths Factory
Harper Collins

To get the full value from these programs it is best if they are first demonstrated carefully by teachers, with different examples being explored with the whole class.

Timings

When used for INSET with a group of teachers, this session will last for 80 minutes.

Section 1

80 mins

Setting the scene: Handling data

There are many ways of teaching children to handle data, but the skills do have to be taught. You cannot assume that they will be 'picked up' automatically. All too often, children spend time on data collection and presentation but little or none on the more important skill of interpretation.

Teachers can help children to understand what lists, tables, charts and diagrams are showing them by using ready-made (secondary) sources, or collecting first-hand (primary) data. The teacher may, for example, suggest that there are always more green Smarties in a tube than any of the other colours. The children can make a block graph to record the numbers of different coloured Smarties found in the tube and report their findings.

What to do [tutor]

- Show video sequence 4, a series of clips from lessons in Years 2 to 6 showing children organising data in different ways. The clips are jumbled, and do not follow age order or progression. After showing the video, give out AS 3.1 and AS 3.2a and 3.2b. Ask the teachers to — 30 mins

work in pairs to discuss the range of activities they have seen and put the extracts in order of progression. They can refer to the Supplement of Examples: Years 1, 2 and 3, pages 90–93, and the Supplement of Examples: Years 4, 5 and 6, pages 112–117.

- Take feedback from the pairs on how they have ordered the video activities. Write on a flip chart the consensus agreement on order of progression. — 10 mins
- Ask everyone to look at the Handling Data booklet, which shows sample activities using pictograms, block graphs, bar charts and Venn and Carroll diagrams. Tell them that the emphasis in the booklet is on interpreting data, drawing conclusions and explaining results, and that they should eventually take the time to work through all the examples in it. Ask them to select one or two of the tasks to try out now. — 20 mins
- Ask the pairs to think back to the video clips they have seen, and consider how the teachers emphasised these important aspects of handling data. Show OHT 3.3 to summarise the session. — 20 mins

Tutor's notes

Video sequence 4 shows a series of nine handling-data activities in Years 2 to 6, with children organising data in different ways. One possible order that teachers might suggest for the sequences is as follows.

1 Clip D: Year 2 children make a simple block graph showing what six- and seven-year-olds like to drink.
2 Clip F: Year 3 children use a Venn diagram to sort shapes into triangles and non-triangles.
3 Clip C: Year 3 children use a bar chart to show how children travel to school. Each point on the vertical axis represents 10 children.
4 Clip B: Year 4 children sort plane shapes into a Carroll diagram using two criteria.
5 Clip I: Year 4 children make a bar chart recording their estimates of a metre. They consider the intervals required on the horizontal axis, based on data they have collected.
6 Clip A: Year 5 children interpret graphs showing continuous data (changes in light and temperature over time).
7 Clip G: Year 5 children make a bar chart with intervals labelled in 2s, 5s, 10s and 20s, based on discrete data (scores on a dice rolled 100 times).

8 Clip H: Year 6 children use Hutchinson's Encyclopaedia to search and find the ten highest mountains in the world, then discuss the table of results.

9 Clip E: Year 6 children interpret a simple pie chart presented from the data in a computer database. They answer questions that the teacher sets.

What to do [self study]

Watch video sequence 4, a series of nine clips of handling-data activities in years 2 to 6. In the lessons, children organise data in different ways. The clips are jumbled so they do not follow age order or progression. Think about the range of activities you have seen and look at the objectives listed in AS 3.2a and 3.2b, then put the extracts in order of progression. If necessary, refer to the Supplement of Examples: Years 1, 2 and 3, pages 90–93 and the Supplement of Examples: Years 4, 5 and 6, pages 112–117. Make notes in your notebook on why you chose that order, then look at the breakdown of the video above and compare it with your notes.

Look at the Handling Data booklet showing sample activities using pictograms, block graphs, bar charts, and Venn and Carroll diagrams. Select one or two of the tasks to try out.

Think back to the lessons you saw on the video and consider how the teachers emphasise the importance of interpretation, drawing conclusions and explaining results when teaching the handling of data. Read the summary on OHT 3.3.

Summary

- There is a range of ways in which teachers can introduce and consolidate handling-data skills with children.
- Handling-data skills – particularly interpretation – have to be taught. Children do not just 'pick them up'.
- ICT is particularly effective when used to demonstrate organising and interpreting data.
- Teachers must support the demonstration with clear explanations and well-targeted questioning. This can stimulate pupil discussion and invite predictions and interpretation of what is displayed.

Progression in handling data

Video clip	Notes on what is shown
A	
B	
C	
D	
E	
F	
G	
H	
I	

Correct order of progression								
1	2	3	4	5	6	7	8	9

AS 3.2a

Handling data: teaching objectives from Years 2 to 4

Year 2

- **Solve a given problem by sorting, classifying and organising information in simple ways, such as in a list or simple table, in a pictogram, in a block graph. Discuss and explain results.**

Year 3

- **Solve a given problem by organising and interpreting numerical data in simple lists, tables or graphs. These should include simple frequency tables, pictograms, bar charts, and Venn and Carroll diagrams (one criterion).**

Year 4

- **Solve a problem by collecting quickly, organising, representing and interpreting data in tables, charts, graphs and diagrams, including those produced by a computer, including tally charts, frequency tables, pictograms, bar charts, and Venn and Carroll diagrams (two criteria).**

AS 3.2b

Handling data: teaching objectives from Years 5 and 6

Year 5

- Solve a problem by representing and interpreting data in tables, charts, graphs and diagrams including those produced by a computer, including bar line charts where intermediate points have no meaning (such as scores on a dice rolled 50 times) and where they may have meaning (such as room temperature over time).
- Find the mode of a set of data.

Year 6

- Solve a problem by representing, extracting and interpreting data in tables, graphs, charts and diagrams, including those generated by a computer, for example: line graphs (e.g. for distance/time, for a multiplication table, a conversion graph, a graph of pairs of numbers adding to 8); frequency tables and bar charts with grouped discrete data (e.g. test marks 0-5, 6-10, 11-15…).
- Find the mode and range of a set of data.
  Begin to find the median and mean of a set of data.

Summary

- There is a range of ways in which teachers can introduce and consolidate handling-data skills with children.
- Handling-data skills – particularly interpretation – have to be taught. Children do not just 'pick them up'.
- ICT is particularly effective when used to demonstrate particular mathematical concepts and ideas.
- Teachers must support the demonstration with clear explanations and well-targeted questioning. This can stimulate children's discussion and invite predictions and interpretation of what is displayed.

Chapter 4 ICT supporting work in shape and space

Introduction

Going on means going far
Going far means returning
Tao Te Ching

A child's first geometrical discoveries are topological ... if you ask him to copy a square or a triangle, he draws a closed circle.
Jean Piaget

This session deals with ICT that supports the teaching of position, directional language, pattern and symmetry. It is in two parts. The first part involves estimating and comparing measures of length, distance, angle and so on. For example, children are asked to devise a sequence of instructions to move a floor robot or screen 'turtle' along a path, and to modify their instructions in the light of the robot's response. The second part covers using ICT to support children who are experimenting with the properties of pattern in shape and space, such as software that transforms shapes and creates geometric patterns.

Young children are often unaware of their position in a room and are surprised and delighted to be asked to behave like a programmable robot following a track or path. They soon develop simple vocabulary such as 'forward, a bit more, stop, turn, come back, not that way, this way' when they start out. Large spaces such as the hall or playground are useful for early exploration.

This can be followed up with a range of tasks, such as using play mats with roads mapped out on them and moving vehicles around. It also

helps to use computer programs such as 'Logo' that allow the children to plot routes and tracks traced out on the screen. They introduce the notion of how a turn can be precisely described and, later, measured as an 'angle'.

Understanding of shape and space can be developed with older children by helping them to focus on pattern, symmetry and transformation. Everyday objects reflect the contribution patterns make. Tiling patterns are ageless and have drawn upon designs and contributions from many different cultures. We can see evidence of this in carpets, fabric, wall coverings and wrapping paper.

Teachers can offer many opportunities for children to experience pattern and working with angles and symmetry. If children are creating these patterns from raw materials, the task can be time-consuming. ICT can create, develop and adapt patterns much more quickly. By using ICT, teachers can focus on the knowledge and conceptual understanding behind the activities rather than on the practical work of design. Software that explores symmetry, reflection and transformation also helps children to become more precise in using related geometrical language, allows them to test and modify a hypothesis quickly and efficiently, makes it possible for them to draw shapes accurately and can encourage them to recognise reflective symmetry.

Timings

When used for INSET, the whole session lasts 90 minutes. There are two sections of 45 minutes each. Everyone should cover Section 1. In Section 2 there are two options: Option 1 for Key Stage 1 teachers and Option 2, for Key Stage 2 teachers.

Section 1

45 mins

Setting the scene: Positional and directional movement

A good way to introduce children to the concept of position is to ask them to follow instructions – provided by the teacher or other children – that give pointers and direction for a route or track, using everyday words to describe position and direction: 'I am standing 5 steps from the door facing the window'. Later, children can be asked to find the shortest or longest route around an obstacle course. Such activities can be undertaken by a whole class working in small groups in a hall or the playground, and provide good opportunities to share and discuss planning.

Tasks can be extended by asking the children to estimate the number of steps they take in each direction. This activity helps prepare children for using a programmable robot, because they need to give directions and distances to make it move. Teachers can model the robot by following one of the simple routes or even knocking over some skittles in front of the robot.

Children with experience of these activities can develop the concept further by using software to carry out similar activities on screen. Not all children need to be involved in the ICT activity, just those who will benefit from further practice. Alternatively, the teacher could use the program as an assessment device, to see if the children have understood the concepts they have been taught.

The Framework emphasises the importance of young children developing language that accurately describes spatial concepts in the objectives below.

Reception

- Use everyday words to describe position.

Year 1

- Use mathematical vocabulary to describe position, direction and movement.
- Talk about things that turn. Make whole turns and half turns.
- Compare two lengths ... by direct comparison.

Several simple programs support this type of activity. Those illustrated below are easily available.

Freddy Teddy
Topologika

Strawberry Garden: Thomas the Clown
Longman Logotron

The Postman: Thomas the Clown
Longman Logotron

Unit the Robot, Star Tower
Apple/Xemplar

Many schools also have access to programmable robots such as 'PiP' and 'Roamer' which are battery driven and also can be used with a pencil or pen to mark a trace.

What to do [tutor]

Before you start, make sure that the teachers are familiar with a programmable robot. They should know how it is programmed and how to use the pen or pencil option to leave a trace of its journey. If they are not familiar with the robot, you should give a short demonstration.

- Talk about the main points raised in 'Setting the scene' above. 5 mins
- Display OHT 4.1 and allow time for it to be read. Show video sequence 5, of Becky in a Worcestershire school. She is working with her class of 30 Year 1 children to develop the language associated with distance, direction and turn. The activity is further developed with a small group of children giving a floor robot instructions to follow a particular route. 15 mins
- Give out AS 4.2. Ask the teachers to work in twos or threes to consider how the teacher in the video managed the various activities listed and what they would need to do to make a success of similar activities. Take feedback from the groups. Summarise the session using OHT 4.3. 25 mins

What to do [self study]

If you are not familiar with programmable robots and the pen or pencil option they contain, take time to become familiar with how one works before you begin.

Run through the main points in 'Setting the scene' (above), then look at OHT 4.1 and watch video sequence 5. This shows Becky working with 30 Year 1 children in a Worcestershire school to develop the language associated with distance, direction and turn. A small group of children give a floor robot instructions to follow a particular route.

Look at AS 4.2. Consider how the teacher in the video managed the listed activities and what you would need to do to adapt them as a successful part of your daily mathematics lesson. Make notes in your notebook, then look at OHT 4.3, which summarises this session.

Summary

- Children need practical experience of seeing and predicting – with support – the direction in which an object moves, the distance it travels and how it turns.
- Children must have the opportunity to use the language of position in relationship to other objects and to compare this relationship using everyday language.
- The use of ICT in the form of a programmable robot can help children to visualise ideas about direction, distance and angle of turn, to make predictions and test them.

Understanding the concepts of shape and space

Young children can be helped to develop concepts of shape and space by being given opportunities to:

- talk about movement – forward and back;
- talk about direction – right and left;
- describe position and its relation to other objects – near, nearer, far, further, too far;
- use a robot to practise the activities developed in Physical Education;
- use ICT to give directions and to place objects in given positions;
- identify right angles.

Teachers should plan to:

- provide a good range of practical activities;
- focus on helping children use the relevant mathematical vocabulary more precisely.

AS 4.2

Programming position and movement

This is a list of the tasks carried out by the children in the video. Go through the list and consider how you would organise your class to carry out the same or similar tasks.

1. **Give and follow instructions to guide the teacher or another child to move.**
2. **Give and follow specific instructions to guide the teacher or another child around a particular route.**
3. **Direct a programmable robot to another child in as few moves as possible.**
4. **Demonstrate how to program the robot and how to estimate the number of 'steps' to get it to complete its journey.**
5. **Plan a second and third journey, changing where the robot will go.**
6. **Program the robot to knock over skittles in as few moves as possible.**
7. **Follow a simple route, using program cards to estimate the moves needed. Test the program and explain what happened.**

Summary

- Children need practical experience of seeing and predicting – with support – the direction in which an object moves, the distance it travels and how it turns.

- Children must have the opportunity to use the language of position in relation to other objects and to compare this relationship using everyday language.

- The use of ICT in the form of a programmable robot can help children to visualise ideas about direction, distance and angle of turn, to make predictions and to test them.

Section 2

45 mins Option 1 – Key Stage 1 teachers

What to do [tutor]

- Display OHT 4.4. Load the 'Strawberry Garden' program from the CD-ROM and select level one. Ask the group to listen to Thomas, who narrates how to use the game, then to suggest directions to help you collect a strawberry and give further instructions for collecting the rest of the strawberries. 10 mins
- ***Option 1a*** Load 'Unit the Robot' from the CD-ROM. Choose either 'Balloon Popping' or 'Apple Picking'. Select 'Practice' to experiment with controlling Unit. Ask the group to work in pairs to devise a set of instructions to pop the balloons or pick the apples. They should test and refine their instructions until they succeed. 15 mins
- ***Option 1b*** Load 'Unit the Robot' from the CD-ROM. Choose either 'Balloon Popping' or 'Apple Picking'. Select 'Program' and develop the sequence of commands for popping the balloons or picking the apples. They should test and refine their instructions until they succeed. 15 mins
- Give out AS 4.5a after the 'Strawberry Garden' activity. Give out AS 4.5b (after Option 1a) or AS 4.5c (after Option 1b). Ask pairs to complete the sheet, considering how they could use aspects of the program in their daily mathematics lesson to develop the objectives in OHT 4.4. Take feedback from the groups. 15 mins
- Summarise using OHT 4.6. 5 mins

What to do [self study]

Look at OHT 4.4. Load the 'Strawberry Garden' program from the CD-ROM and select level one of the game. Listen to Thomas who narrates how to use the game. Try out directions to help you collect a strawberry. Give further instructions for collecting the rest of the strawberries.

Option 1a Load 'Unit the Robot' from the CD-ROM. Choose either 'Balloon Popping' or 'Apple Picking'. Select 'Practice' to experiment with controlling Unit. Devise a set of instructions to pop the balloons or pick the apples. Test and refine your instructions until you succeed.

Option 1b Load 'Unit the Robot' from the CD-ROM. Choose either 'Balloon Popping' or 'Apple Picking'. Select 'Program' and develop the sequence of commands for popping the balloons or picking the apples. Test and refine your instructions until you succeed.

Look at AS 4.5a after the 'Strawberry Garden' activity. Look at AS 4.5b (after Option 1a) or AS 4.5c (after Option 1b). Complete the appropriate sheets, considering how you could use aspects of the program in your daily mathematics lesson to develop the objectives in OHT 4.4. Make notes in your notebook and look at OHT 4.6, which summarises this section.

Summary

- Young children need experience of directing an object precisely, using right, left, forward and back in a sequence, with support.
- Some young children will be able to plan and sequence a route using direction, distance and turn.
- ICT can provide children with an environment in which they can make predictions, test them out and make changes in light of their findings.

A selection of objectives for shape and space

Year 2

- Use mathematical vocabulary to describe position, direction and movement.
- Recognise whole, half and quarter turns, to the left or right, clockwise or anti-clockwise.
- Give instructions for moving along a route in straight lines and round right-angled corners.

Year 3

- Read and begin to write vocabulary to describe position, direction and movement.
- Make and describe right-angled turns.

AS 4.5a

Organising the use of 'Strawberry Garden'

Consider what you would have to do to organise the following tasks and how you could integrate this program into your daily mathematics lesson.

1 **Use Thomas's narrative to introduce 'Strawberry Garden' to the whole class.**

2 **Collect a strawberry, with the children helping at each step.**

3 **Collect two more strawberries with help from the children.**

4 **Set the task for a small group who need further practice to collect the rest.**

5 **Finish the lesson by discussing with the whole class how you might record a set of instructions to collect the strawberry. Record the suggestions on the board.**

AS 4.5b

Organising the use of 'Unit the Robot' – Practice Mode

Consider what you would have to do to organise the following tasks and how you could integrate this program into your daily mathematics lesson.

1 **Read the instructions for controlling 'Unit the Robot' to the whole class.**

2 **Select 'Practice' and either 'Balloon Popping' or 'Apple Picking'. Give instructions to pop a balloon or pick an apple, with the children helping at each step.**

3 **Work until most of the balloons are popped or apples picked.**

4 **Set the task for a small group who need further practice to collect the rest.**

5 **Finish the lesson by discussing with the whole class the set of instructions they needed to complete the task. Ask them how they compared with the instructions to complete 'Strawberry Garden'.**

AS 4.5c

Organising the use of 'Unit the Robot' – Program Mode

Consider what you would have to do to organise the following tasks and how you could integrate this program into your daily mathematics lesson.

1 **Read the instructions for controlling 'Unit the Robot' to the whole class.**

2 **Select 'Program' and either 'Balloon Popping' or 'Apple Picking'. Plan instructions to pop a balloon or pick an apple with the children helping at each step. Test and refine the instructions until you succeed.**

3 **Work until most of the balloons are popped or apples picked.**

4 **Set the task for a small group who need further practice to complete the rest.**

5 **Finish the lesson by discussing with the whole class the set of instructions they used. Ask them to consider whether they could have used fewer instructions to complete the task. Encourage them to explain their answers.**

Summary

- Young children need experience of directing an object precisely, using right, left, forward and back in a sequence, with support.
- Some young children will be able to plan and sequence a route using direction, distance and turn.
- ICT can provide children with an environment in which they can make predictions, test them out and make changes in light of their findings.

45 mins

Option 2 – Key Stage 2 teachers

What to do [tutor]

- Display OHT 4.7. Load the 'VersaTile' demonstration program from the CD-ROM and create an irregular shape that will need adjusting into another shape. Give out AS 4.8 which shows a set of examples. Ask the teachers to load 'VersaTile' from the CD-ROM and follow the instructions. Explain that the program is a demonstration version and is therefore time-limited to 10 minutes and will not work after this time without reloading the program. 25 mins
- Give out AS 4.9 and ask the group to consider the organisation required to use 'VersaTile' successfully in their daily mathematics lesson. Then ask, 'How would you use this program to teach some of the objectives listed on OHT 4.7?' Take feedback. 15 mins
- Show OHT 4.10 to summarise the session. 5 mins

What to do [self study]

Look at OHT 4.7. Load the 'VersaTile' demonstration program from the CD-ROM. Look at AS 4.8, which shows a set of examples of what 'VersaTile' can do. Work through the four examples, bearing in mind that the program is time limited to 10 minutes and will not work after this time without reloading the program. The first task is to create an irregular polygon, then edit the shape. Next, clear the screen and create a new shape by choosing the number of sides it will have. Draw the new shape on the screen and use the Zoom option to enlarge it. The next step is to create a simple pattern that can be reflected in a horizontal or vertical line. Try out these reflective patterns and mark on them the line(s) of symmetry. Finally, you have to create a tile and translate it repeatedly along a line.

Look at AS 4.9 and consider the organisation required to use 'VersaTile' successfully in your daily mathematics lesson. Consider how you would use this program to teach some of the objectives listed on OHP 4.7. Make notes in your notebook and look at OHT 4.10, which summarises the session.

Summary

ICT can help children understand shape and pattern by providing opportunities for them to:

- create a shape that will tessellate;
- understand why certain shapes do not tessellate;
- create a pattern from reflecting regular shapes;
- devise patterns, then reflect and translate them
- try out their ideas;
- get rapid feedback.

A selection of objectives for shape and space

Year 3

- Identify right angles.
- Identify lines of symmetry in simple shapes and recognise shapes with no lines of symmetry.

Year 4

- Classify polygons, using criteria such as number of right angles, whether or not they are regular, symmetry properties.

Year 5

- Recognise parallel and perpendicular lines, and properties of rectangles.
- Recognise reflective symmetry in regular polygons.
- Complete symmetrical patterns with two lines of symmetry at right angles.
- Recognise where a shape will be after a translation.

Year 6

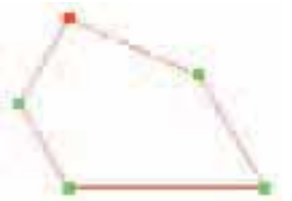
- Classify quadrilaterals, using criteria such as parallel sides, equal angles, equal sides.
- Recognise where a shape will be after reflection.
- Recognise where a shape will be after two translations.
- Recognise where a shape will be after a rotation through 90° and about one of its vertices.

AS 4.8

Examples of the use of 'VersaTile'

Example 1

Choose the straight line tool and create an irregular polygon by clicking on the screen where you want the corners to be.



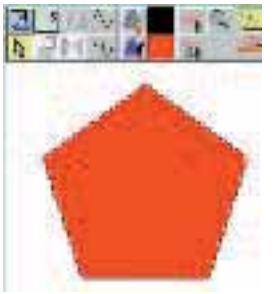
Under the Edit menu, Select All and Edit Shape. Drag the corner points to change the shape.

Edit the shape to make another shape.

Example 2

Create a new shape by choosing the number of sides it will have.

Draw the new shape on the screen.

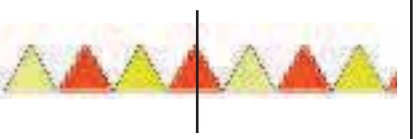


Use the Zoom option to enlarge the shape.

Example 3

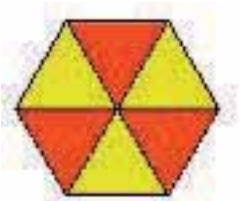
Create a simple pattern that can be reflected in a horizontal or vertical line.

Under the Edit menu, Select All, Group and Copy. Move your cursor to where you want the pattern to be repeated.



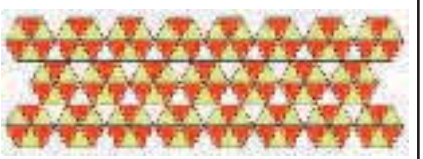
Try out your reflective pattern and mark on the line(s) of symmetry.

Example 4



Create a tile based on a defined shape. (To rotate a shape, right click your mouse.)

Under Edit, Select All, Group and Copy. Move your cursor to where you want the copied tile to appear and click.



Translate the tile repeatedly along a line.

AS 4.9

Organising the use of 'VersaTile'

Here is a list of tasks making use of 'VersaTile'. Consider how you could integrate each of them into your daily mathematics lesson.

1 **Teacher demonstrates 'VersaTile' to show how the program can repeat patterns from a shape provided.**

2 **Start with a shape and make a repeated pattern with it.**

3 **Ask the children to begin with a new shape that needs adapting, then to tell you how to adapt it. Make a repeated pattern with the shape they have adapted.**

4 **Extend the task so that the computer program creates a simple pattern and it can be reflected in a horizontal or vertical line of symmetry.**

5 **Create a tile and translate it repeatedly along a line. Predict and discuss the patterns made.**

Summary

ICT can help children understand shape and pattern by providing opportunities for them to:

- **create a shape that will tessellate;**
- **understand why certain shapes do not tessellate;**
- **create a pattern from reflecting regular shapes;**
- **devise patterns, then reflect and translate them;**
- **try out their ideas;**
- **get rapid feedback.**

Chapter 5 ICT supporting problem solving

Introduction

The value of a problem is not so much coming up with the answer as in the ideas and attempted ideas it forces on the would-be solver.
N. Herstein

It isn't that they can't see the solution. It is that they can't see the problem.
G.K. Chesterton

This session looks at how ICT can be used to encourage children in Key Stages 1 and 2 to investigate and solve mathematical problems, develop their mathematical vocabulary and explain their reasoning. There are several ways of going about this. One is to solve a problem presented in a computer program, such as finding a strategy for buying stamps at a post office or using coins in a toy shop. Another is to use a computer program to solve number puzzles, such as filling a given number of carriages on a train with a given number of people. A third possibility is to use a computer program to investigate and generalise a number relationship, for example the number of times a bouncing ball will touch the sides of a billiard table.

Objectives for problem-solving skills

These selected objectives from the *Framework* for Years 2 and 4 emphasise the development of problem-solving skills, particularly as regards making decisions (about what method to use to solve a problem, for instance) and developing the ability to reason, predict and explain.

Year 2

- Choose and use appropriate operations and efficient calculation strategies (mental, mental with jottings) to solve problems.
- Solve mathematical problems or puzzles, recognise simple patterns and relationships, generalise and predict. Suggest extensions by asking 'What if ...?' or 'What could I try next?'
- Investigate a general statement about familiar numbers or shapes by finding examples that satisfy it.
- Explain how a problem was solved orally and, where appropriate, in writing.

Year 4

- Choose and use appropriate number operations and appropriate ways of calculating (mental, mental with jottings, paper and pencil) to solve problems.
- Explain methods and reasoning orally, and where appropriate in writing.
- Solve mathematical problems or puzzles, recognise simple patterns and relationships, generalise and predict. Suggest extensions by asking 'What if ...?'
- Make and investigate a general statement about familiar numbers or shapes by finding examples that satisfy it. Develop from explaining a generalised relationship in words to expressing it in a formula using letters as symbols (for example the cost of n articles at 15p each).

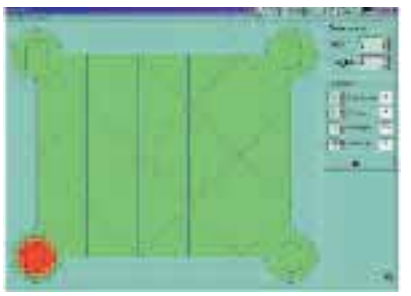
A range of programs support the development of problem-solving skills, including those illustrated below.

Toy Shop
Using ICT to support mathematics: Programs CD-ROM

The Postman: Thomas the Clown
Longman Logotron

The Jolly Postman's Party
Dorling Kindersley

Robots Day: Steps, Maths Factory
Harper Collins

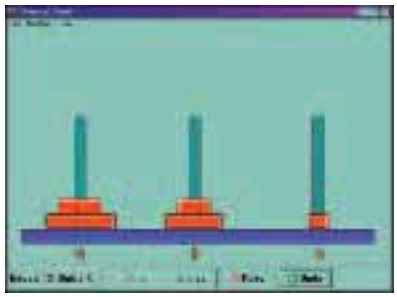


Bounce
Using ICT to support mathematics: Programs CD-ROM

LOGO: Lesson Maker
EduTech

Numberbox
Blackcat

Frogs
SMILE



Hanoi
SMILE

Boat
SMILE

The full value of these programs is best seen as a teacher demonstration tool where different examples can be readily explored and feedback provided.

Timings

When used for INSET with a group of teachers, this session will last for 100 or 140 minutes. It has three sections, one of which is optional. Section 1 takes 55 minutes, Section 2 takes 45 minutes and the optional third section takes 40 minutes. It is suggested that the session is organised over the whole morning of a training day.

Section 1

55 mins

Setting the scene: Problem solving – Year 2

Younger children have to be taught problem-solving skills; you cannot assume that they will be 'picked up' automatically. Computer simulations can help here. You might start by setting a problem with a limited number of solutions. A simple example is to investigate a postman's possible routes through a village delivering birthday invitations. Each solution is discussed, and the teacher helps the class

reach a consensus on which is the best. The children analyse the problem, work out a strategy, arrive at a solution (this could be mentally or with paper and pencil), and compare their solution with others.

Later, more complex problems, ones that involve balancing a greater number of variables, can be introduced, such as a simulation of moving people by boat from one side of a river to the other when the boat only holds a given number of people.

What to do [tutor]

Before you start, set up the computer and connect it to a large-screen monitor, television or projector.

- Display OHT 5.1 showing the objectives for developing problem-solving skills with Year 2 children. Load 'Toy Shop' from the CD-ROM and run it on Level 3 (coins including £2). Divide the group in two and explain that the purpose of the program is to win toys by making the last payment. Ask the two groups in turn which coins to pay, and ask group members what mathematical skills and knowledge they used to arrive at their solution. Encourage everybody to use precise mathematical language when describing their methods. Play the game two or three times. 20 mins
- Show video sequence 6, an extract of part of a lesson by Karen, a teacher working with a Year 2 class in Coventry. She is introducing the children to the 'Toy Shop' program. She is working with the class to demonstrate the idea of choosing coins to pay for a toy. She explains to a group how to use the program and that to win the toy they have to lay down the last coin. Discuss with the group how the teacher introduced the mathematical skills the children would need to play and win the game, and how effective they were. How does this work match the objectives shown on OHT 5.1? 20 mins

- Ask the group to consider how they could use programs such as this to develop problem-solving skills in Key Stage 1. Take feedback and record on a flip chart. Show OHT 5.2 to summarise the session. 10 mins
- Look at sample lessons 12 and 13 using 'Toyshop'. How do these reflect on what has been discussed in this session? 5 mins

What to do [self study]

Look at OHT 5.1, showing the objectives for developing problem-solving skills with Year 2 children. Load 'Toy Shop' from the CD-ROM and set it on Level 3 (coins including £2). If possible, find someone to play the game with you. The purpose of the program is to win toys by making the last payment. Play the game several times until you are confident in using it. Consider what mathematical skills and knowledge you used to arrive at your solutions. Make notes in your notebook.

Watch video sequence 6, showing Karen introducing the children in her Year 2 class in Coventry to the 'Toy Shop' program. She is working with the class to demonstrate the idea of choosing coins to pay for a toy, and explains to a group that to win the toy they have to pay the last coin. Consider how the teacher introduced the mathematical skills the children would need to play and win the game. How effective were they? How does this work match the objectives on OHT 5.1? Make notes in your notebook.

Consider how you could use programs such as this to develop problem-solving skills in Key Stage 1. Look at OHT 5.2, which summarises the section, and then at sample lessons 12 and 13 using 'Toyshop'. How do these reflect on what you have seen in this session? Make notes in your notebook.

Summary

- Problem-solving skills have to be taught and are not just 'picked up' by children.
- It is important to consolidate early problem-solving skills by presenting children with a progression of increasingly more complex tasks.
- ICT is effective when it is used by the teacher to demonstrate particular mathematical concepts and ideas.
- Teachers should support the demonstration by clear explanation and well-targeted questioning. This can stimulate pupil discussion and invite predictions and interpretation of what is displayed.

Year 2 – objectives for problem solving

- Choose and use appropriate operations and efficient calculation strategies to solve problems.
- Solve mathematical problems or puzzles, recognise simple patterns and relationships, generalise and predict. Suggest extensions by asking 'What if ...?' or 'What could I try next?'
- Investigate a general statement about familiar numbers or shapes by finding examples that satisfy it.
- Explain how a problem was solved orally and, where appropriate, in writing.

Summary

- Problem-solving skills have to be taught and are not just 'picked up' by children.
- It is important to consolidate early problem-solving skills by presenting children with a progression of increasingly more complex tasks.
- ICT is effective when it is used by the teacher to demonstrate particular mathematical concepts and ideas.
- Teachers should support the demonstration by clear explanation and well-targeted questioning. This can stimulate children's discussion and invite predictions and interpretation of what is displayed. The children analyse the problem, work out a strategy, arrive at a solution (this could be mentally or with paper and pencil), and compare their solution with others.

Section 2

45 mins Problem solving – Year 4

What to do [tutor]

- Display OHT 5.3, looking at the objectives for the development of problem-solving skills in Year 4. Show video sequence 7, an extract of a lesson taught by Anne-Marie, working with a Year 4 class of 30 children in a school in Coventry. She introduces the children to the 'Play Train' program demonstrating the idea of filling carriages with passengers using restricted numbers. Later you see her working with a small group of children. — 15 mins
- Split the group into threes or fours to discuss, first how the work done away from and at the computer complemented each other, and secondly which objectives shown on OHT 5.3 have been addressed. If they have not all been addressed on the video, then how might they be addressed? Take feedback from the groups and ask them to compare what they have seen with their own practice. — 15 mins
- Load 'Play Train' from the CD-ROM into a computer connected to a large-screen monitor, TV or projector. Run the program on Level 2 (two numbers and a limited number of carriages). Explain that the purpose of the activity is to fill the carriages with the required number of passengers using the given two numbers, and that each carriage must have passengers in it before the train will move. Run the program, taking input from the group on how to fill the carriages. Ask members of the group to explain how they arrived at their solution. Ask the group to pose questions that might challenge children further. For example, are there certain numbers of carriages that would be more difficult to fill? What is a good strategy for filling the carriages? Which of the strategies are most efficient? How many different strategies can you think of? Display OHT 5.2, which summarises this section. — 10 mins
- Finish by looking at sample lessons 4 and 5, using 'Play Train', and discuss how these reflect the issues raised in this session. — 5 mins

What to do [self study]

Look at OHT 5.3, which focuses on the objectives for developing problem-solving skills in Year 4.

Watch video sequence 7, an extract of a lesson taught by Anne-Marie, working with a Year 4 class of 30 children in a school in Coventry. She introduces the children to the 'Play Train' program demonstrating the idea of filling carriages with passengers using restricted numbers. Later you see her working with a small group of children.

After watching the video, think about how the work done away from and at the computer complemented each other, and which of the objectives shown on OHT 5.3 have been addressed. If they have not all been addressed on the video, then how might they be addressed?

Set up the computer and load 'Play Train' from the CD-ROM. Run the program on Level 2 (two numbers and a limited number of carriages). The purpose of the program is to fill the carriages with the required number of passengers using the given two numbers. Each carriage must have passengers in it before the train will move. Run the program, and work out how to fill the carriages. Jot down how you arrived at your solution.

Think of some questions that might challenge children further. For example, are there certain numbers of carriages that would be more difficult to fill? What is a good strategy for filling the carriages? Which of the strategies are most efficient? How many different strategies can you think of?

Look at OHT 5.2, which summarises this section, and finish by looking at sample lessons 4 and 5, using 'Play Train', and think about how they reflect the issues raised in this session. Make notes in your notebook.

Summary

- Problem-solving skills have to be taught and are not just 'picked up' by children.
- It is important to consolidate early problem-solving skills by presenting children with increasingly more complex tasks.
- ICT is effective when it is used by the teacher to demonstrate particular mathematical concepts and ideas.
- The teacher supports the demonstration by clear explanation and well-targeted questioning. This can stimulate pupil discussion and invite predictions and interpretation of what is displayed.

OHT 5.3

Objectives for the development of problem-solving skills in Year 4

- Choose and use appropriate number operations and appropriate ways of calculating (mental, mental with jottings, paper and pencil) to solve problems.

- Explain methods and reasoning orally, and where appropriate in writing.

- Solve mathematical problems or puzzles, recognise and explain patterns and relationships, generalise and predict. Suggest extensions by asking 'What if ...?'

- Make and investigate a general statement about familiar numbers or shapes by finding examples that satisfy it. Develop from explaining a generalised relationship in words to expressing it in a formula, using letters as symbols (for example the cost of *n* articles at 15p each).

Section 3 (optional)

40 mins Problem solving – Years 5 and 6

What to do [tutor]

- Display OHT 5.4, which shows the objectives for developing problem-solving skills in Years 5 and 6.
- Load 'Bounce' from the CD-ROM into a computer connected to a large-screen monitor, TV or projector. Set the table to have a width of 8 and a height of 6 and ask the group to work out the number of bounces the ball will make before entering a pocket (the starting position counts as the first bounce). Fill the other boxes with any guessed numbers at this stage. 20 mins
- Set the table to have a width of 6 and a height of 8. Ask the group to predict the answer. Test out their predictions.
- Set the table to have a width of 4 and a height of 4. What does the group notice about the number of bounces this time?
- Split into smaller groups and ask each of them to consider how they would use this program to set up an investigation with Year 6 children, either the whole class or a selected group. What task would they set? How does this work match the objectives shown on OHT 5.4? 10 mins
- Conclude the session by taking feedback from the groups, discussing any points that arise. 10 mins

What to do [self study]

Look at OHT 5.4, which shows the objectives for developing problem-solving skills in Years 5 and 6. Load 'Bounce' from the CD-ROM and set the table to have a width of 8 and a height of 6. Work out the number of bounces the ball will make before entering a pocket (the starting position counts as the first bounce). Fill the other boxes with any guessed numbers at this stage.

Now set the table to have a width of 6 and a height of 8. Predict the answer. Test out your prediction.

Set the table to have a width of 4 and a height of 4. What do you think will be the number of bounces this time?

Make notes in your notebook on how you would use this to set up an investigation with Year 6 children. What task would you set?

Consider how you could use a program such as this with your whole class or with a group. How does this work match the objectives shown on OHT 5.4? Make notes in your notebook.

Objectives – problem-solving skills

Year 5

- Choose and use appropriate number operations to solve problems and appropriate ways of calculating: mental, mental with jottings, written methods, calculator.
- Explain methods and reasoning orally and in writing.
- Solve mathematical problems or puzzles, recognise and explain patterns and relationships, generalise and predict. Suggest extensions by asking 'What if …?'
- Make and investigate a general statement about familiar numbers or shapes by finding examples that satisfy it. Explain a generalised relationship (formula) in words.

Year 6

- Make and investigate a general statement about familiar numbers or shapes by finding examples that satisfy it. Develop from explaining a generalised relationship in words to expressing it in a formula, using letters as symbols (e.g. the cost of *n* articles at 15p each).

Appendix 1 The National Numeracy Strategy *Framework for teaching mathematics: Reception to Year 6* – references to ICT

Information and communications technology (ICT)

ICT includes the calculator and extends to the whole range of audio-visual aids, including audio tape, video film and educational broadcasts. You can use ICT in various ways to support your teaching and motivate children's learning. For example, by using a computer, children in Key Stages 1 and 2 can:

- explore, describe and explain number patterns, for example by watching a counting 'meter' with sequences of numbers shown slowly one at a time, or experimenting with patterns of multiples highlighted on different number grids;
- practise and consolidate their number skills, for example by using software designed to 'teach' or practise a particular skill and give rapid assessment feedback to you and them;
- explore and explain patterns in data, for example by accessing, displaying and interpreting ready-made sets of data, displaying quickly a bar chart or pictogram showing the outcome of a class vote, or using a sensor connected to a computer to measure, display and show trends in room temperature;
- estimate and compare measures of length or distance, angle, time, and so on, for example by devising a sequence of instructions to move a floor robot or screen 'turtle' along a path, then modifying their instructions in the light of the robot's response;
- experiment with and discuss properties of patterns in shape and space, for example by using software to transform shapes and create geometric patterns, or watching a film of a square being halved in different ways;
- develop their mathematical vocabulary, logical thinking and problem-solving skills, for example by using a 'branching tree' computer program to sort shapes or numbers, or exploring a simple simulation to discover the mathematical relationship that underpins it.

An aim of the daily mathematics lesson is to keep the class working together and to link – but limit to no more than three – the number of different activities going on during group work. Most schools with children in Key Stages 1 and 2 do not have sufficient computers for all the children in a class to do the same activity simultaneously, but you or another adult can make good use of a single computer in the daily lesson by working with the whole class, if the monitor's screen is large enough. An alternative is for you to work with part of the class – perhaps a group of six to eight children. As with other ways of teaching mathematics, your role is to demonstrate, explain and question, stimulate discussion, invite predictions and interpretations of what is displayed and ask individual children to come to the keyboard to enter an instruction or a response.

A small group of children working together can also make effective use of one or two computers in the daily mathematics lesson, provided that the activity is consistent with the lesson's objectives, the activities of other groups and the overall number of activities. You need to intervene in the computer work from time to time to teach and develop the children's learning, and make sure that they are all participating. You should also invite them to contribute to the plenary part of the lesson. Individual use of computer programs is usually inappropriate in the daily lesson, except where children with profound special educational needs or exceptional ability are doing individualised work. But programs which allow any child to practise number skills independently, or to investigate a mathematical problem with a partner, have a valuable part to play in breaks and after-school clubs, and at home.

You should use computer software in your daily mathematics lesson only if it is the most efficient and effective way to meet your lesson's objectives. For example, an aimless exploration of an 'adventure game', or repetitive practice of number bonds already mastered, is not good use of lesson time. And it is time-consuming for children to develop their understanding of addition and subtraction by taking turns to instruct a floor robot to move along a number track; a much quicker way of achieving the same mathematical objective is for as many children as possible to walk up and down the track, and to observe others doing so.

The supplements of examples that are part of the Framework include some references to ICT, where its use can be managed efficiently by a teacher working with a whole class or a large group, and the activity helps to deliver the National Curriculum for ICT. Specific programs are scarcely mentioned, since the focus in the supplements is on mathematical outcomes, not the resources that can be used to achieve them. But you could annotate the supplements of examples in

suitable places with references to the software and other resources that you have in school.

ICT is, of course, more than a teaching tool. For many children with special educational needs it is an essential communication aid. The Internet offers teachers access to research articles and materials to download for classroom use, such as mathematical problems for children to solve with accompanying notes for teachers. The web-sites of the mathematical associations give useful information and can guide you to other useful sites. The development of the National Grid for Learning, which will include the Virtual Teacher's Centre, will also offer schools practical sources of advice and the opportunity to exchange ideas with others.

References to ICT in the *Supplements of examples*

Reception

COUNTING AND RECOGNISING NUMBERS

Reading and writing numbers

- Point to 8 on a clock face, in this pack of shuffled cards, on a calculator key-pad, on the 'shop' till, on the telephone, on the computer keyboard, on a video recorder …

SOLVING PROBLEMS

Reasoning about numbers or shapes

- Use sets of shapes, printing, collage, weaving, bead threading, computer programs or other media to make own repeating patterns …

SHAPE AND SPACE

Patterns and symmetry

- Talk about and recreate simple patterns made from people, beads, shapes, sounds… or by using computer programs…
- Make patterns from thin plastic shapes, gummed paper shapes, felt shapes, mosaic shapes, pegs and pegboard… by using a computer program…

Years 1, 2 & 3

NUMBERS AND THE NUMBER SYSTEM

Counting, properties of numbers and number sequences

Year 1

- Point to 9 on the number line, on the clock face, in this pack of shuffled cards... on a telephone, computer keyboard...

Year 3

- Use a number grid computer program to display multiples of 2, 5, 10… on a 10 × 10 grid, and describe the patterns made.

CALCULATIONS

Mental calculation strategies (× and ÷)

Year 3

- Observe and describe the effect of multiplying and dividing by 10, using an abacus, an OHP calculator or multibase apparatus to develop patterns as on this grid:

SOLVING PROBLEMS

Reasoning about numbers or shapes

Year 2

- Solve a problem presented in a computer program: for example, find a strategy for buying stamps at a post office or using coins in a toy shop.

Year 3

- Use a computer program to develop a strategy for rearranging the order of objects: for example, to change over two sets of 'frogs' in a line.

SHAPE AND SPACE

Movement and angle

Year 3

- Use a tiling computer program to create a pattern which is repeated along a line. Reflect the tile in one axis, and describe how the pattern changes.

HANDLING DATA

Organising and using data

Year 3

- Use the data in a frequency table linked to a problem the class is trying to solve. Make – or use a computer to make – a simple bar chart, with the vertical axis labelled in ones, then twos.
- Decide what data is needed, collect it quickly then make – or use a computer to make – a simple pictogram, where the symbol represents 2 units.
- Use a computer with a simple graphing program to enter and display data. Discuss how quickly the computer can do it and which chart, graph or table shows the information best.

Years 4, 5 & 6

NUMBERS AND THE NUMBER SYSTEM

Ordering (whole numbers)

Year 5

- Use knowledge of place value and number operations to place digits in the best position to make the largest/smallest sum, difference, product or quotient, using either a calculator or a computer program.

NUMBERS AND THE NUMBER SYSTEM

Properties of numbers

Year 4

- Use a number grid computer program to highlight multiples. Use different sizes of grid to explore multiples of 2. Describe and explain which grids produce 'diagonal' patterns, and which produce 'vertical' patterns. Try multiples of 3.

Year 5

- Use a number grid computer program to highlight and explore multiples on different sizes of grid. Describe and explain the patterns produced.

NUMBERS AND THE NUMBER SYSTEM

Properties of numbers and number sequences

Year 6

- Use a computer program to identify or define a number chosen by the computer, using knowledge of number properties such as being greater or less than a given number, being odd, even, prime, square, a multiple of…, a factor of…

NUMBERS AND THE NUMBER SYSTEM

Fractions

Year 4

- Recognise that one whole is equivalent to two halves, three thirds, four quarters… For example, build a fraction 'wall' using a computer program and then estimate parts.

NUMBERS AND THE NUMBER SYSTEM

Fractions and decimals

Years 5 and 6

- Use a computer program to zoom in and out of a number line, and position and order decimals.

CALCULATIONS

The only references to ICT are through 'use a calculator to ...'

SOLVING PROBLEMS

Reasoning about numbers and shapes

Year 4

- Use a computer program to solve number puzzles: for example, to fill a given number of carriages on a train with given numbers of people.

Year 5

- Use a 'binary tree' computer program to sort a set of numbers according to their properties.

Year 6

- Use a computer program to investigate and generalise a number relationship: for example, the number of times a bouncing ball will touch the sides of a billiard table.

MEASURES

The only references to ICT are through 'use a calculator ...'

SHAPE AND SPACE

Properties of 3-D and 2-D shapes

Year 5

- Use a 'binary tree' computer program to sort and identify a set of 2-D shapes.

SHAPE AND SPACE

Reflective symmetry, reflection and translation

Year 4

- Use a computer program to:
  - create a pattern and reflect it in a horizontal or vertical line;
  - create a 'tile' and translate it repeatedly along a line.

Predict and discuss the patterns made.

Year 5

- Use a computer program to create a 'tile' and use it by alternately translating the tile and its reflection along a line. Predict and discuss the patterns made.

Year 6

- Use a computer program to transform shapes. Predict and discuss the patterns made.

HANDLING DATA

Organising and interpreting data

Year 6

- Begin to interpret simple pie charts, such as those showing the data in a computer database.
- Find the mode and range of a simple set of data in a computer database. Begin to find the mean and median.
- Make a simple computer database. Transfer the results of a spelling test and a mental test to it and then use its facilities to find out, for example:
  - Who scored more than 7?
  - What were the frequencies of scores of 10, 9, 8…?
  - What was the most common score (the mode)?
  - What was the difference between the greatest and least scores (the range)?
  - What was the middle score (the median)?
  - What was the mean score (the sum of all the scores divided by the total number of scores)?

- In other subjects, test hypotheses by interrogating data in prepared computer databases, such as census data or data on road safety.
- Use the facilities of the database to compare and contrast the presentation of data in different charts or graphs, deciding which is best for its purpose. Discuss the efficiency of a computer database compared with searching and sorting a paper database.

Appendix 2 The National Numeracy Strategy *Framework for teaching mathematics: Reception to Year 6* – references to calculators

Information and communications technology (ICT)

ICT includes the calculator and extends to the whole range of audio-visual aids, including audio tape, video film and educational broadcasts.

The role of calculators

The calculator is a powerful and efficient tool. It has a strong part to play in subjects such as geography, history and science, since it allows children of primary age to make use of real data – often numbers with several digits – that they have gathered in their research or experiments, perhaps to work out a percentage, or to compare totals or proportions.

In the primary years, the calculator's main role in mathematics lessons is not as a calculating tool, since children are still developing the mental calculation skills and written methods that they will need throughout their lives. But it does offer a unique way of learning about numbers and the number system, place value, properties of numbers, and fractions and decimals. For example, you could use an overhead projector calculator for whole-class demonstration purposes so that the class can predict what happens when they multiply by 10 or divide by 10, or individual children might use a calculator to find two consecutive numbers with a given product and then discuss their different approaches.

If children are to use the basic facilities of a calculator constructively and efficiently, you need to teach them the technical skills they will require: the order in which to use the keys; how to enter numbers such as sums of money, measurements or fractions; how to interpret the display; how to use the memory; etc. Children need to learn when it is, and when it is not, appropriate to use a calculator, and their first-line strategy should involve mental calculations wherever possible. For example, you might show children that they can 'beat the calculator' if they can recall number facts rapidly. They should also have sufficient

understanding of the calculation in front of them to be able to decide which method to use – mental, pencil and paper, or calculator. When they do use a calculator they should be able to draw on well-established skills of rounding numbers and calculating mentally to gain a sense of the approximate size of the answer, and have strategies to check and repeat the calculation if they are not sure whether it is right.

For these reasons, schools should not normally use the calculator as part of Key Stage 1 mathematics but should emphasise oral work and mental calculation. But by the end of Key Stage 2, children should have the knowledge and competence to use a calculator to work out, say, (56 + 97) ÷ (133 – 85) and round the answer to one decimal place. They should also recognise that an approximate answer is 150 ÷ 50, or 3, and use this to check their calculation.

References to calculators in the *Supplements of examples*

Years 4, 5 & 6

NUMBERS AND THE NUMBER SYSTEM

Place value (whole numbers)

Year 5

- Put in your calculator display:
  ninety-nine thousand, five hundred and two;
  two hundred and fifty-two thousand and forty.

- What needs to be added/subtracted to change:
  47 823 to 97 823; 207 070 to 205 070?
  Use your calculator. Make the change in one step.

NUMBERS AND THE NUMBER SYSTEM

Place value (whole numbers and decimals)

Year 5

- Observe and comment on the effect of multiplying or dividing by 10 or 100 using a calculator.

Year 6

- Observe and comment on the effect of multiplying or dividing by 10, 100 or 1000 using a calculator.

NUMBERS AND THE NUMBER SYSTEM

Ordering

Year 5

- Use knowledge of place value and number operations to place digits in the best position to make the largest/smallest sum, difference, product or quotient, using either a calculator or a computer program.

NUMBERS AND THE NUMBER SYSTEM

Negative numbers

Year 5

- Recognise negative numbers on a calculator.
- Use the constant function to generate sequences of negative numbers.

NUMBERS AND THE NUMBER SYSTEM

Properties of number, number sequences

Year 5

- Count on or back from any number in steps of 19, 21 or 25. Predict what will come next each time. What do you notice?
  Do the same using the constant function on a calculator to generate multiples of, say, 55 or 70

Year 6

- Use a calculator to respond to questions such as:
  – Find which number, when multiplied by itself, gives 2809.
  – Find two consecutive numbers with a product of 9506.
  – The area of a square is 256 cm^2. What is the length of its side?

NUMBERS AND THE NUMBER SYSTEM

Fractions and decimals

Year 5

- Using a calculator, in one step (operation), change:
  7.82 to 7.86… 15.35 to 15.75… 5.3 to 53… 89 to 8.9…

- Enter fractions into a calculator and interpret the display to find the equivalent decimal. Predict the result before confirming.
  For example:

$^1/_2$	one half	0.5
$^1/_4$	one quarter	0.25
$^3/_4$	three quarters	0.75
$^1/_{10}$	one tenth	0.1
$^1/_5$	one fifth or two tenths	0.2
$^1/_{100}$	one hundredth	0.01
$^{75}/_{100}$	75 hundredths or three quarters	0.75

$^{3}/_{100}$	three hundredths	0.03
$^{50}/_{100}$	fifty hundredths or one half	0.5

- Appreciate that a number like 3.6 in a calculator display means £3.60 in the context of money, and that 67p is entered as 0.67 since it is $^{67}/_{100}$ of £1.

Year 6

- Using a calculator, in one step (operation), change:
  4.7 to 470… 530 to 5.3… 0.3 to 0.03… 7 to 0.07… 60 to 0.6…

- Continue to enter fractions into a calculator and interpret the display to find the equivalent decimal. Predict the result before confirming. For example:

$^{1}/_{1000}$	one thousandth	0.001
$^{1}/_{8}$	one eighth	0.125
$^{1}/_{3}$	one third	0.3333333
$^{2}/_{3}$	two thirds	0.6666666

- Use a calculator to compare fractions. For example:
  – Which of these two fractions is less?
    $^{7}/_{8}$ or $^{4}/_{5}$ $^{3}/_{4}$ or $^{11}/_{14}$
  – Place these fractions in order:
    $^{7}/_{20}$ $^{6}/_{15}$ $^{13}/_{14}$ $^{8}/_{25}$

NUMBERS AND THE NUMBER SYSTEM

Fractions, decimals and percentages

Year 6

- With a calculator answer questions such as:
  – Find 20% of £362. Find 75% of 850.

CALCULATIONS

Understanding addition

Year 5

- Use mental or written methods or a calculator to:
  – find the missing number in:
    531 + □ + 160 = 746
  – total a shopping bill or set of measurements such as:
    £12.45, £7.36, £24.50
    7.5 km, 55 km, 4.5 km, 28 km

Year 6

- Use mental or written methods or a calculator to:
  – find the missing number in:
    287 + □ + 2485 = 6128

– find all the different totals you can make by using three of these five numbers:
14 721, 76, 9534, 788, 6
1.07, 0.3, 37.03, 17.73, 31.7
– find the average (mean): for example, the average price of some goods, the average of a set of measurements or a set of numbers…

CALCULATIONS

Understanding subtraction

Year 5

• Use mental or written methods or a calculator to:
– find the missing number in:
931 – □ = 746
– find all the different differences you can make by using two of these five numbers:
8, 4008, 562, 3103, 95

Year 6

• Use mental or written methods or a calculator to:
– find the missing number in:
□ – 2485 = 4128
– find all the different differences you can make by using two of these five numbers:
1.07, 0.3, 37.03, 17.73, 31.7

CALCULATIONS

Understanding multiplication

Year 5

• Use written methods or a calculator to work out:
132 × 46 = □ □ × △ = 162
2.7 × 8 = □ (14 × 60) + □ = 850

Year 6

• Use written methods or a calculator to work out:
738 × □639 = □ □ × △ = 9506
(41 × 76) + □ = 4000 78 × (97 – 42) = □

CALCULATIONS

UNDERSTANDING DIVISION

Year 5

• Use written methods or a calculator to work out:
(125 ÷ □) + 2 = 27 (□ ÷ 5) – 22 = 30
900 ÷ 36 = □ 1560 ÷ □ = 120
□/28 = 46

- When dividing with a calculator, interpret the quotient displayed. For example:
  - interpret 8.4 as £8.40 in the context of money;
  - round other decimals to the nearest whole number, recognising, say, 9.714 285 after dividing 68 by 7 as 'between 9 and 10'.

- Examples of rounding down
  - I have saved £240. A train ticket to Durham is £52.
    240 ÷ 52 is 4.615 384 on my calculator.
    I can buy only 4 tickets.

Year 6

- Use written methods or a calculator to work out:
  4123 ÷ 365 = □ □ ÷ 2.8 = 4.6
  (□ ÷ 25) – 22 = 30 (56 + 97)/(133 – 85)
  (100 ÷ □) + 5 = 7.5

- When dividing with a calculator, interpret the quotient displayed. For example:
  - interpret halves, quarters, tenths and hundredths as either decimals or fractions;
  - recognise one third, two thirds and one ninth;
  - round decimals to the nearest whole number or the nearest tenth.

- Examples of rounding down
  - Dad has saved £5000. An air fare to Sydney is £865.
    5000 ÷ 865 is 5.780 346 on my calculator.
    He can buy 5 tickets.

CALCULATIONS

Using a calculator

Year 5

- Use, read and write, spelling correctly:
  calculator, display, key, enter, clear, constant...

- Know how to:
  - clear the display before starting a calculation;
  - Use the [+], [–], [×] and [÷] keys, the [=] key and decimal point to calculate with realistic data;
  - change an accidental wrong entry by using the [clear entry] key;
  - recognise a negative number output;
  - key in and interpret money calculations: for example, key in £4.35 + £3.85 as 4.35 [+] 3.85 [=], and interpret the outcome of 8.2 as £8.20;
  - key in £6.30 + 85p as 6.3 [+] 0.85 [=], recognising that '0.' signals no pounds and only pence (alternatively, change money to pence and divide final answer by 100 to convert back to pounds);

  - begin to select the correct key sequence to carry out calculations involving more than one step: for example, 8 × (37 + 58);
  - know, for example, that a number such as 81.75 lies between 81 and 82;
  - interpret a rounding error such as 6.9999999 as 7;
  - have a feel for the approximate size of an answer, and check it by performing the inverse calculation or by clearing and repeating the calculation.

- Use a calculator to respond to questions such as:
  - The perimeter of a square is 274 cm.
    What is the length of each side?
  - Julie is 92 cm tall. Tom is 184 cm tall.
    Lisa's height is half way between Julie's height and Tom's height.
    Calculate Lisa's height.
  - Write the missing number: 3.42 + □ = 12.1.
  - Emma saves £3.50 each week.
    How much has she saved after 16 weeks?
  - Rupert saves the same amount of money each month.
    He saved £149.40 in a year.
    How much money does he save each month?
  - There are 75 grams of rice in one portion.
    How many portions are there in a 3 kg bag of rice?
  - Find three consecutive numbers which add up to 171.

Year 6

- Use, read and write, spelling correctly:
  calculator, display, key, enter, clear, constant... recurring

- Know how to:
  - use the [clear] and [clear entry] keys, all operation keys, the [=] key and decimal point, to calculate with realistic data;
  - recognise a negative number output and use the [sign change] key where appropriate;
  - key in and interpret the outcome of calculations involving sums of money;
  - key in fractions, recognise the equivalent decimal form, and use this to compare and order fractions;
  - read the display of, say, 0.3333333 as 'point three recurring', know that it represents one third, and that 0.6666666 represents two thirds;
  - start to use the memory and select the correct key sequence to carry out calculations involving more than one operation including brackets:
    for example, (23 + 41) × (87 + 48);
  - have a feel for the approximate size of an answer after a calculation, and check it appropriately.

- Use a calculator to respond to questions such as:
  - The area of a square is 256 cm^2.
    What is the length of each side?
  - Every day a machine makes 100 000 paper clips which go into boxes.
    A full box has 120 paper clips. How many full boxes can be made from 100 000 paper clips?
    Each paper clip is made from 9.2 cm of wire.
    What is the greatest number of paper clips that can be made from 10 metres of wire?
  - 2753 people go to a sports event.
    Each person pays £2.30 for a ticket.
    What is the total amount of ticket money collected?
  - Programmes cost 65p each.
    The total money from programme sales is £612.95.
    How many programmes are sold?
  - Calculate 24% of 525.
- Write the missing number: 568.1 ÷ □ = 24.7.
- Find two consecutive numbers with a product of 1332.

CALCULATIONS

Checking results of calculations

Year 5

- Use a calculator to check:
  - 3685 – 987 = 2698 with 2698 + 987 = 3685;
  - 1650 ÷ 50 = 33 with 33 × 50 = 1650;
  - half of 920 = 460 with double 460;
  - $\frac{1}{5}$ of 300 = 60 with 60 × 5 = 300.

Year 6

- Use a calculator to check:
  - 6.5 – 9.8 = –3.3 with –3.3 + 9.8 = 6.5;
  - 4.8 ÷ 5 = 0.96 with 0.96 × 5 = 4.8;
  - half of 8.1 = 4.05 with double 4.05;
  - $\frac{1}{8}$ of 320 = 40 with 40 × 8 = 320.

SOLVING PROBLEMS

Making decisions

Year 5

- Make and justify decisions:
  - choose the appropriate operation(s) to solve word problems and number puzzles;
  - decide whether calculations can be done mentally or with pencil and paper or a calculator;
  - explain and record how the problem was solved.

Year 6

- Make decisions:
  - choose the appropriate operation(s) to solve word problems and number puzzles;
  - decide whether calculations can be done mentally or with pencil and paper or a calculator;
  - explain and record how the problem was solved.

SOLVING PROBLEMS

Reasoning about numbers and shapes

Year 5

- Each ◆ represents a missing digit.
  Use your calculator to solve:
  ◆◆ × 6◆ = 6272

Year 6

- Use a calculator to solve these:
  a. Each ◆ represents a missing digit. Solve:
  ◆2◆ × ◆◆= 11316
  b. One whole number divided by another gives 1.1818181. What are the two numbers?

SOLVING PROBLEMS

'Real life' problems

Year 6

- Use a calculator or a written method.
  A full box has 180 pins.
  How many full boxes can be made from 100 000 pins?

SOLVING PROBLEMS

Problems involving money

Year 6

- Use a calculator or a written method.
  4030 people go to a football match.
  Each ticket costs £4.25.
  What is the total cost of all the tickets?

- Use a calculator or a written method.
  There are 2560 lira to £1.
  Find the price in lira of a house costing £60 000.

- Use a calculator or a written method.
  There is a 15% discount in a sale.
  How much is the discount on £200... £25...?

SOLVING PROBLEMS

Problems involving measures

Year 5

- Use a written method or a calculator to solve, for example:
  – There is 2.2 kg of sugar in a bag.
    How much sugar is there in 10 bags?

Year 6

- Use a written method or a calculator to solve, for example:
  – A pin is made from 14 mm of wire.
    How many pins can be made from 1 m of wire?
  – There are exactly 2.54 cm to 1 inch.
    1 yard is 36 inches.
    About how many centimetres are there in 1 yard?
  – A garage orders 50 000 litres of petrol.
    It sells an average of 1250 litres per day.
    How long does its supply of petrol last?

MEASURES

Area and perimeter

Year 6

- Respond to oral or written questions like:
  – Find the length, breadth and height of this box.
    Use a calculator to find its surface area.

Appendix 3 Using large-screen computer displays in the daily mathematics lesson

Introduction

With the much greater emphasis now on whole-class teaching and the development of suitable software to address specific objectives, the question many teachers are asking is, 'How can I make the most effective use of ICT in my mathematics lessons?' Practicality is the issue, making sure that all children can see the display clearly.

There are several ways to increase the size of the display. This can be achieved in the following ways:

- using overhead calculators developed for use with an overhead projector;
- connecting the computer to a large-screen TV set;
- connecting the computer to an interactive whiteboard;
- connecting the computer to a digital projector;
- connecting the computer to a Liquid Crystal Display panel.

Each of these solutions is discussed below, with examples of how they might be used in whole-class teaching of mathematics.

Issues for consideration before deciding on which solution is best for your school are also included, and a list of suppliers is provided as well as details of where to get technical information.

Interactivity

In the case of both the interactive whiteboard and the overhead calculator, children can fully interact with the technology. Using any of the other solutions will enable children to see the result of the teacher or child's input to a keyboard.

Using an overhead calculator with an Overhead Projector (OHP)

As part of their work on place value and decimals, a Year 5 class has been exploring the effect of multiplying and dividing numbers by 10 and 100. The teacher is especially keen to emphasise the fact that the digits move one place to the left when multiplied by 10 and two places to the left when multiplied by 100. Using a special overhead calculator on an OHP the teacher can demonstrate the effect to the class who can all see the display clearly.

In another school, a class of Year 6 children is developing a greater understanding of inverse operations. In the context of a game their teacher sets them the task of finding six numbers that will satisfy this inequality:

$5 < (45 + \square) < 9$

During the plenary session of the lesson children are asked to demonstrate their calculations and explain their thinking using the overhead calculator.

POINTS TO CONSIDER

- An overhead calculator facilitates interactivity.
- It is not recommended that calculators be used for calculations before Year 4.
- Overhead calculators are designed to be used with specific pocket calculators so that the keys the children see projected match those on their calculators. If your class is particularly large you may have to share the calculators one between two children.
- Overhead calculators are not robust and should be kept in the case provided.
- If your school has a newer flatbed OHP, the calculator may overheat and the display could be distorted.
- The cost of an overhead calculator starts at below £20. (Corresponding hand-held calculators will cost between £2 and £3 each.)

Using your school's large-screen TV

A Year 6 class is working on reasoning about numbers and shapes. The teacher is using the program 'Bounce'. The class are investigating and generalising various number relationships, for example:

- How many times will the billiard ball touch the sides of the table?
- Into which pocket will the ball drop?

To make sure the class can clearly see the path of the billiard ball, the teacher decides to connect her computer to the school's large-screen TV using a special connection cable. As the teacher enters information into her computer the TV screen acts as a large monitor.

POINTS TO CONSIDER

- Detailed material can lack clarity because of the low resolution of the screen.
- Bright light in the classroom may make the screen difficult to see clearly.
- The principal advantage of using the school's TV set is one of cost. The connection cable is relatively cheap, and can be purchased for about £125. This solution also makes use of your school's existing resources.

Using an interactive whiteboard

In Year 2 the children are learning to reason about numbers. The teacher is using 'Toyshop' to develop their understanding. Her computer is connected via a projector to an interactive whiteboard at the front of the class. The whiteboard acts as a large-screen display; all the children can see it clearly. Two children come to the whiteboard to play the game. The whiteboard is interactive, so the children only need to touch the coins on the whiteboard to activate the computer. Because the rest of the class can see the children touch the coins they are able to relate cause and effect and can easily contribute to discussions on the strategies being used by the children playing the game.

POINTS TO CONSIDER

- An interactive whiteboard facilitates interactivity.
- Do you have a fixed whiteboard or a mobile one?
  A fixed board screwed to the wall is useful in a large room. An additional advantage with a fixed whiteboard is that the projector can be ceiling mounted. Having a fixed screen means you will have to bring children (and any other equipment you might need) to the screen.

  A mobile board is mounted on castors for ease of movement. The projector can sit on any suitable surface, but bear in mind that you or the children can easily get in the way of the projection.

- How big should the board be?
  A very large board isn't always an advantage in a primary school where space is often at a premium. Additionally, to take full advantage of the interactive element of the whiteboard, teachers and children need to be able to touch the screen. A very large board might make it difficult for children to reach all parts of the board.

  Have you got any tight corners to negotiate? Large boards are not so manoeuvrable.

- How sensitive is the board to input?
  Do you need to use a special board pen or can you activate it with your fingernail? Children using the interactive board might cope better initially if they do not need to use a special input device.

- Is there a separate keyboard link?
  Some boards have infra-red or lead-driven pads that can be used from anywhere in the classroom, negating the need for the teacher or children to stand at the board in order to use it.

- Cost – as interactive whiteboards are a relatively recent development they are still quite costly, however prices are coming down.

Using a digital projector

A Year 3 class is learning to classify shapes according to their properties. The children have already had lots of practical experiences with shapes. The teacher has decided to use a computer program to help children sort shapes according to their angle properties. He links his computer to a digital projector that will project the image on the computer monitor onto a screen, whiteboard or light-coloured wall. His children can all see the different shapes quite clearly, and are able to classify the shapes. The teacher asks different children to come to the computer and, using the mouse, to place the shapes in the appropriately labelled column. The rest of the class can watch what is happening on the projection.

POINTS TO CONSIDER

- The projection is large and clear enough for more detailed material to be displayed. This will be particularly important when using some types of software.

- Connection to a computer is not difficult.

- The projectors are not very heavy and are easily carried from room to room. Ease of carrying will have security implications for schools.

- Bright light in the classroom may make the projection difficult to see clearly.

- Projectors are costly. The prices range from about £1200 to over £8000. The price of the projector tends to reflect the resolution, brightness and weight of the projector.

Using a Liquid Crystal Display (LCD) panel

A Year 5 class is exploring number patterns on a grid. Their teacher uses 'Monty' to help develop their knowledge and understanding. He connects his computer to a special panel that sits on top of the OHP. The computer display is now projected through the OHP onto a light-coloured surface. The children can clearly see the numbers on the grid and can predict the numbers that are obscured by Monty's body. The projection is large and clear enough for more detailed material to be displayed.

POINTS TO CONSIDER

- Connection to a computer is not difficult.
- The panels are not very heavy and are easily portable from room to room. This may have security implications for schools.
- They are quite fragile.
- Specific leads may be needed for each type of computer so if your school has a range of computers it may be quite costly (and confusing) to provide connecting cables for each.
- Bright sunlight in the classroom may make the display difficult to see clearly.
- Panels are relatively expensive, costing from about £850 to £1200.

Technical information

Connection to a large-screen TV set may require the purchase of a computer to TV converter card and connection cables.

Using an LCD panel requires an OHP with a minimum of 400W.

Suppliers

Full technical information and approximate prices are available from an information sheet at

http://www.becta.org.uk/technology/infosheets/pdf/largescreen.pdf

Appendix 4 Developing understanding of decimals in Year 4 using portable ICT equipment

The school

The school involved in this part of the project is a first school for 4-9 year olds. It is situated on a local authority housing estate with a relatively high level of unemployment. The proportion of pupils receiving free school meals is over 50%. The buildings date from the early 1900s.

The teacher

The teacher has been at this school for nine years. She has taught different year groups in the first school age range, though she has been teaching Year 4 for the past few years. She valued the experience of teaching younger pupils and considers that this experience played a significant part in her professional development.

> "Actually moving classrooms and seeing how children learn from an earlier age has been one good thing, because you can see how they are going to progress and develop."

She also values the contribution to her development through working with supportive colleagues.

> "We are a very open kind of staff, in the sense that everybody helps everybody else. If anybody says, 'Look, I'm stuck with this' or 'Have you got a good idea for that?'; that does help you with your ideas."

Her subject responsibilities are music and English. She does not consider that she is particularly skilled at ICT and says she learnt "by trial and error" at first. Prior to the start of the project, she was somewhat apprehensive about trying to use ICT. This was because of some negative experiences using older equipment which had been unreliable. She is, however, positive about the importance of ICT in pupils' education.

> "I'm keen that they can achieve a whole lot more than they do at the minute."

She also acknowledges the importance of planning for ICT and having clear subject objectives for pupils.

> "If you're going to use it effectively, you've really got to be able to plan for a group to be using a computer, and you've got to have it planned into the literacy hour and the numeracy hour so that there is a time to concentrate on something yourself as well".

The pupils

There are 24 pupils in the class and they range in ability from one who is on Stage 2 of the SEN register through to a few higher attaining pupils. The majority of them are typical lively, bouncy and inquisitive 8-9 year olds who sometimes find it difficult to concentrate for extended periods.

Introducing pupils to decimals on a number line

The aim of the project

The teacher wanted to introduce the class to decimal notation. She then wanted them to be able to order decimal numbers. This was the primary aim of the project. She originally thought that most of the pupils would only cope with one place of decimals with perhaps just a few working with numbers with two places of decimals, especially in relation to money.

The need to use real data

One of the teacher's main concerns about introducing the children to numbers with two decimal places was the issue of how meaningful the pupils would find the numbers. Sums of money can be written as numbers with two decimal places; however, it is easy to overlook the decimal notation. £1.24 is not seen as a single number of pounds but rather as two closely related numbers: one pound and, separately, twenty four pennies. This interpretation explains the common error of writing the amount as £1.24p. The teacher felt that it was important to use numbers where the pupils could draw some understanding from the context. She found it difficult to determine a context using length which met these criteria. After discussing the challenge, the possibility of using time in seconds measured to two decimal places was identified as an area to explore.

The teacher's choices

The teacher began with a whole class session using a number line to identify points with decimal values. A group of pupils then worked on the ICT-supported activity while other pupils completed related activities using decimals such as those from the Abacus mathematics scheme which the school uses.

The teacher chose an ICT activity which used an e-Mate connected to a pressure-mat sensor. This allowed the children to generate times in seconds to two places of decimals. The pressure mat acted as a switch to start and stop the timer which was displayed in large digits on the screen of the portable computer. The children could control the timer easily by tapping on the interactive screen with the computer's stylus or 'pen'. This activity was therefore planned to take advantage of the *interactivity*, and *the speed and automatic functions* of ICT. The pupils could make and use accurate measurements easily so that they could concentrate on thinking about and interpreting the results at a level which was appropriate to their current understanding.

The teacher was confident that the pupils would manage this activity, having taught them to organise themselves to complete similar tasks in the past.

The pupils using the e-mate as a timer

Other timing equipment, such as a digital stopwatch, could have been used by the pupils. However, the advantage of the sensor was that the pupils did not need to be able to use a timer accurately as the data logging software simplified the process. In addition, the aim of the initial activity was for the pupils to be able to order decimals. This equipment timed different activities easily without the need for any comparison of, or calculation with, their starting and finishing times.

How long can you stay in the air?

The ICT equipment enabled two different types of activities to be timed, each of which needed different interpretations as to which was the 'best'. The first activity required the children to stand on the

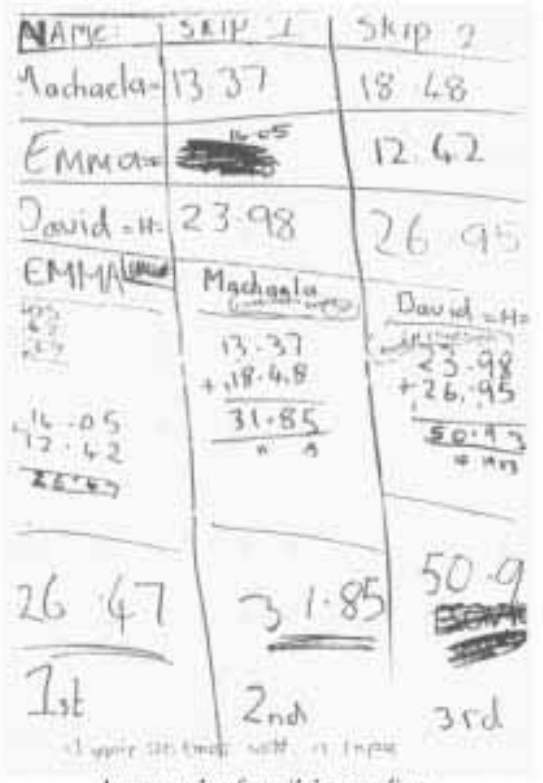
pressure mat, they then zeroed the clock and jumped in the air before landing on the mat again. The times for these standing jumps were typically 0.43 or 0.37 seconds. The element of competition required the pupils to interpret the times to determine which was best. In this example, the 'best' time was the biggest number - the longest time in the air. The personal stake in achieving this is an aspect of the activity which needs to be emphasised!

The second activity used the portable nature of the equipment: the children used the ICT equipment as a timing gate. They took it out into the playground and ran from one side to the other and back again. When they trod on the mat to set off, the timer was started. It stopped when they returned and trod on it for the second time. On this occasion the 'best' time was the smallest number: the shortest time taken.

Very quickly the pupils suggested further uses for the equipment, both indoors and out. They subsequently invented various activities which needed to be timed. They added the resulting decimal times, they ordered them and then they eventually completed subtraction calculations with them!

How quickly can you get back?

The example below is the recording sheet from a skipping exercise they devised. This involved standing on the mat to start the timer, running, picking up a rope, skipping 20 times, and then standing on the mat again to stop the timer. It soon became very clear that fairness of testing also became a crucial element of their planning! The teacher noted the potential links with aspects of the science programmes of study. The teacher wanted the pupils to record their results on paper so that other pupils could make comparisons with their own times. This led naturally to them wanting to calculate with the numbers to work out who was best overall.



An example of pupils' recording

The role of ICT

The teacher chose to use the ICT equipment for two reasons: the first was to generate 'real' numbers which the children could understand from the context in which they were produced;

Recording the results on paper

the second was as a stimulus to get the children thinking about what 'best' meant and about using decimals in a specific context to achieve this. She also wanted to use aspects of the published scheme which the school uses as part of its approach to

mathematics throughout the school, but to make links to understanding decimals through the ICT activity.

Using the ICT also had an effect upon the choices related to the teacher's expectations of the children. She had not done a lot of work on decimals with previous Year 4 classes. This, she thought, might have been related to her own needs as well as those of the children.

> "I found decimal fractions quite difficult for a lot of children. It may be the fact that I didn't expect them to take it much further was part of my problem as well.

This use of ICT offered the children an opportunity to generate decimals in a context which they could not only relate to but could also understand. It also meant that the teacher now had the chance to change her expectations of how far she pushed them in their learning.

> "The activity with the e-Mate stimulated their interest to learn and understand beyond my expectations. I would never in my wildest dreams have thought they would cope with this."

A plenary discussion reviewing what pupils had learned

Not only were her expectations of what the whole class could achieve altered, but there were also some significant changes for individuals. She found that certain children were succeeding much more in relation to their peers with this activity than in previous activities. This led her to review her pedagogy in which an important feature of her general approach was the way that she not only used whole class sessions to review what pupils had done in sessions, but also to identify and focus pupils on areas to develop in the next lesson.

> "I think, for instance, with the work on decimals with the e-Mate, there was always the opportunity, after they'd done their individual group activities, to talk to the rest of the class about what they'd done. Different groups would invent something different to do with the e-Mate, perhaps a slightly different activity, so there was always the fact that they would be coming back to pass it on."

She also used her observation and analysis of pupils' work to inform her teaching so that she could correct errors and misunderstandings.

> "I think using the children's errors has so much mileage in it... I sometimes make it a whole class teaching point before I start the lesson of the next day, because I've had time to mark, and I've had time to see who has made certain errors. I can go back and say, 'Look, let's sort this out'."

Results from the testing

In the second term of the project the pupils completed a standardised mathematics test. The results indicate that the mean number age has gone up from 8 years and 4 months to 9 years and 5 months. This gain was achieved in four months. (The difference is statistically significant at <.001 level.) The test did not specifically look at using decimals, although it was a component of the test. Whilst it is important not to attribute this gain solely to the ICT activities, it is reasonable to suggest that they played a part in developing specific mathematical skills and understanding. In addition, it also seems reasonable to assume that the activities also have played a part in the more general increase in the pupils' confidence and attitude. The idea that working on developing one area of mathematics has an unplanned but significantly beneficial effect upon others is consistent with the work of Denvir & Brown (1986) and so is not surprising.

Functions of ICT

The pupils were taking advantage of the *interactivity* which the portable computer, data logging software and pressure mat offered. It removed the barrier that is so often encountered when an intermediate step is needed to generate the data: in this case, an ability to use some sort of timing device. This step can require another set of sophisticated skills and understanding which prevents children from concentrating upon the original task. On this occasion, the children were meant to be focusing on numbers with two decimal places and not on the process of timing; the ICT allowed them to do just that. Thus the mathematical objectives which the teacher had identified remained at the forefront of the children's activities.

The *speed and automatic functions* of the equipment enabled the pupils to measure and record events in the school environment accurately which it would have been difficult to collect without the sensor and data logging software. The teacher chose not to get the pupils to record their times on the computer (such as on a spreadsheet). This was so that the emphasis was on working out the order of the decimal numbers mentally and subsequently on calculating both mentally, and with paper and pencil, using the times they had produced.

This equipment also enabled the teacher to teach some aspects of the controlling, monitoring and modelling strand of the Key Stage 2 programme of study for IT with her pupils.

Summary

The teacher was able to use ICT effectively to address objectives which she had identified as a particular challenge in her teaching of mathematics. The ICT enabled the pupils to understand decimal numbers from the context in which they were generated. The particular equipment simplified the process of timing so that the pupils could manage the data collection with minimal teaching or support. The teacher's conclusion was that using the ICT had been beneficial both for the pupils and for her own understanding of what they could achieve. In addition it is clear that with a specific focus on increasing attainment in mathematics, substantial improvement can be achieved.

> "I think getting into ICT does make you look at different ways of doing things. And you can see that there are sometimes better, quicker, more efficient ways of doing things. Yes, I think I've come to expect more of these children with decimals for a start."

Further reading and information

The National Numeracy Project with Hamilton Education Limited have produced a video entitled 'Numeracy in Action'. The video focuses on the teaching approaches used in the Hamilton Maths Project and the National Numeracy Project. One of the sequences focuses on teaching decimals. (£15.00 - tel.: 01865 396613)

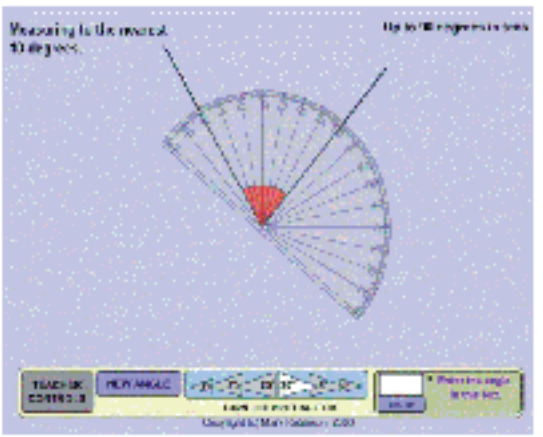
Alan Wigley has some vital recommendations about the importance of correct terminology to use when talking about decimals in the chapter 'Approaching number through language' in Teaching and Learning Early Number edited by Ian Thompson and published by Open University Press (1997). Many of the activities he recommends, such as using arrow cards, can be adapted to decimals.

As a practical resource BEAM publish a booklet 'Exploring Decimals' which has a range of effective activities and teaching points (BEAM tel: 0171 457 5535).

One section of the Teacher Training Agency's Needs Assessment materials for Key Stage 2 teachers 'Assessing your needs in mathematics', also focuses on decimals and is available in booklet form or on CD rom (TTA tel.: 0171 925 3700).

Denvir B. & Brown M. (1986) 'Understanding of number concepts in low attaining 7-9 year olds, Part 1, Development of descriptive framework and diagnostic instrument', Educational Studies in Mathematics, 17:15 - 36.

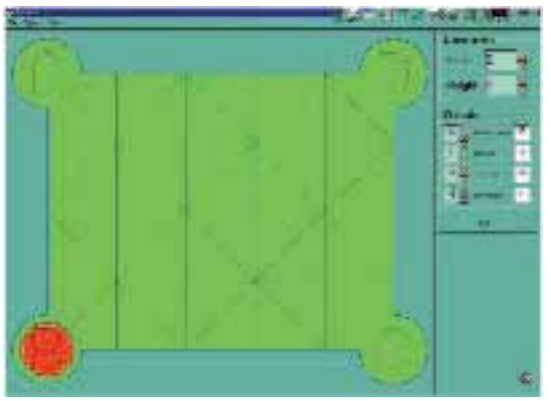
Appendix 5 Software included in the training pack (listed alphabetically by title)



Angle, Mark Robinson

Ambleside C.E. Primary School
Vicarage Road
Ambleside
Cumbria LA22 9DH

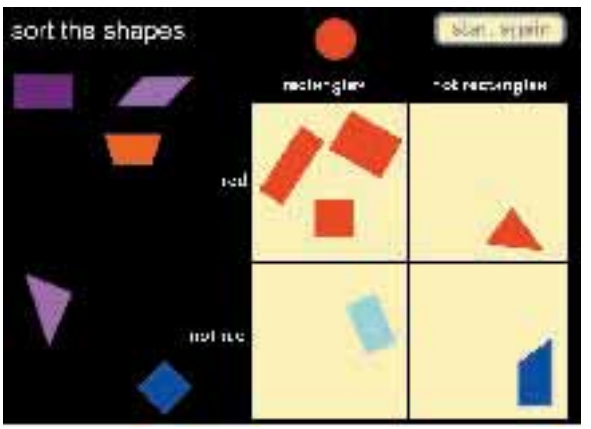
Tel: 01539 432181
URL: http://www.ambleside..schoolzone.co.uk/ambleweb/numeracy.htm



Bounce, Newman College with MAPE

MAPE
Cilgeraint Farm
St Anns
Nr Bethesda
Gwynedd LL57 4AX

This program was originally published as part of the MEP Primary Maths and Micros pack.
Tel: 01248 602655
URL: http://www.mape.org.uk



Carroll Diagram, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

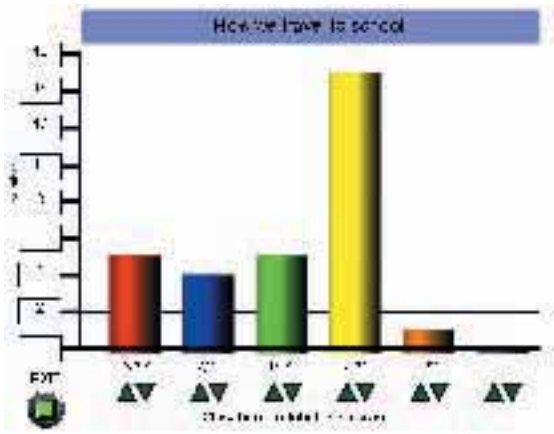
Counter, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

This program was originally published by the ATM as part of the Slimwam 2 Pack

Function Machine, Mark Robinson

Ambleside C.E. Primary School
Vicarage Road
Ambleside
Cumbria LA22 9DH

Tel: 01539 432181
URL: http://www.ambleside.schoolzone.co.uk/ambleweb/numeracy.htm



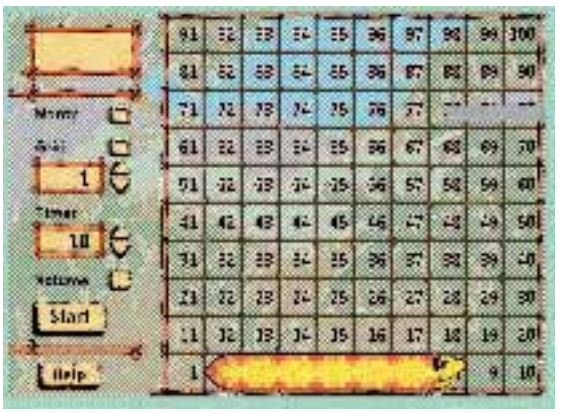
Handy Graph, Mark Robinson

Ambleside C.E. Primary School
Vicarage Road
Ambleside
Cumbria LA22 9DH

Tel: 01539 432181
URL: http://www.ambleside.schoolzone.co.uk/ambleweb/numeracy.htm

Minimax, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

This program was originally published by SMILE Mathematics



Monty, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

This program was originally published by the ATM as part of the Slimwam 2 Pack

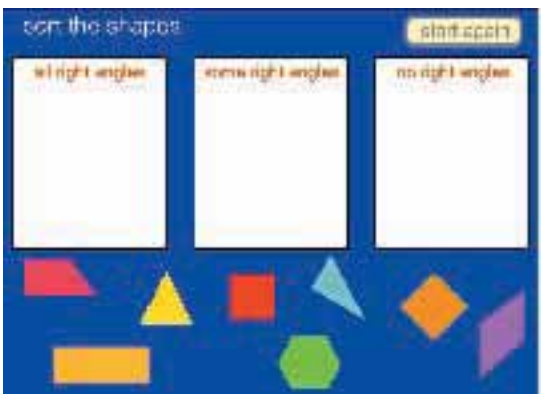
Multiple Machine, Number Works, Sherston Software

Sherston Software Ltd
Angel House
Sherston
Nr Malmesbury
Wiltshire SN16 0LH

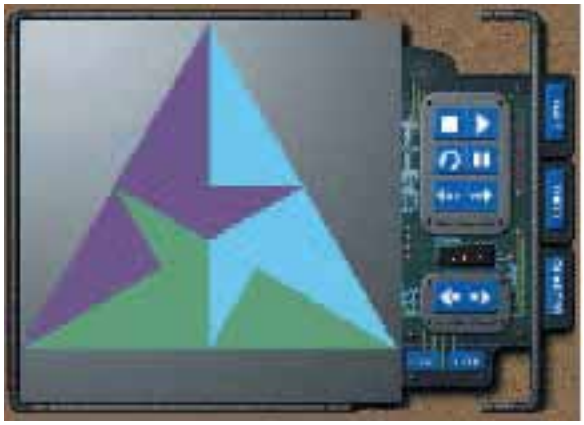
Tel: 01666 843200
Fax: 01666 843216
Email: sales@sherston.co.uk
URL: http://www.sherston.co.uk/

Play Train, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

This program was originally published as part of the MEP Infant Pack

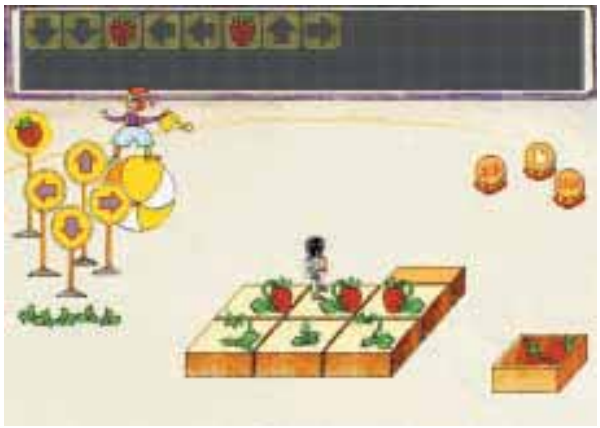


Sorting 2-D Shapes, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa



Take Part, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

This program was originally called 'Take Half' and was published by SMILE Mathematics



Strawberry Garden, Thomas the Clown, Longman Logotron

Longman Logotron
124 Cambridge Science Park
Milton Road
Cambridge CB4 0ZS

Tel: 01223 425558
Fax: 01223 425349
Email: info@logo.com
support@logo.com
sales@logo.com
URL: http://www.logo.com/

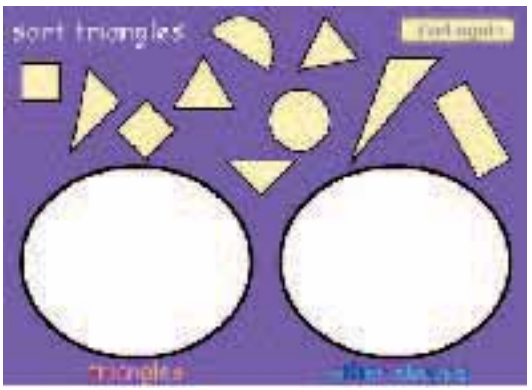
Toy Shop, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa

This program was originally published as part of the MEP Infant Pack

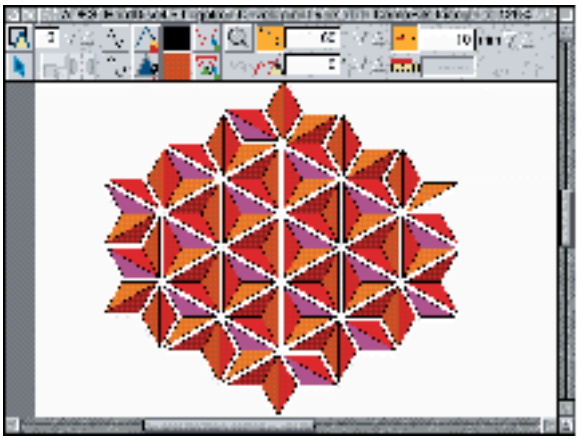
Unit the Robot, Star Tower, Apple/Xemplar

Apple Education
Apple (UK office)
2 Furzeground Way
Stockley Park
Uxbridge
Middlesex UB11 1BB

Tel: 020 8218 1500
Fax: 020 8218 1501
URL: http://www.apple.com/uk/education/schools/



Venn Diagram, 'Using ICT to support mathematics in primary schools'. Software developed by the National Numeracy Strategy and BECTa



VersaTile, Longman Logotron

Longman Logotron
124 Cambridge Science Park
Milton Road
Cambridge CB4 0ZS

Tel: 01223 425558
Fax: 01223 425349
Email: info@logo.com
support@logo.com
sales@logo.com
URL: http://www.logo.com/

All the addresses and contact details were checked by the National Numeracy Strategy on 15 August 2000.

Appendix 6 Hardware and software publishers and suppliers referred to in the training pack (listed alphabetically by title)

Boat, SMILE

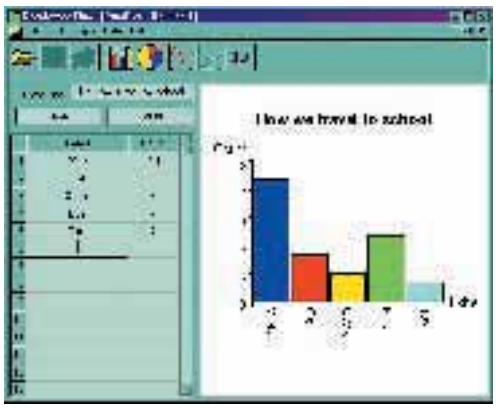
SMILE Mathematics
Isaac Newton Centre
108A Lancaster Road
London W11 1QS

Tel: 020 7598 4841
Fax: 020 7598 4838
Email: info@smilemathematics.co.uk
URL: http://www.smilemathematics.co.uk/

Complement, Developing Number, ATM

The Association of Teachers of Mathematics
7 Shaftesbury Street
Derby DE23 8YB

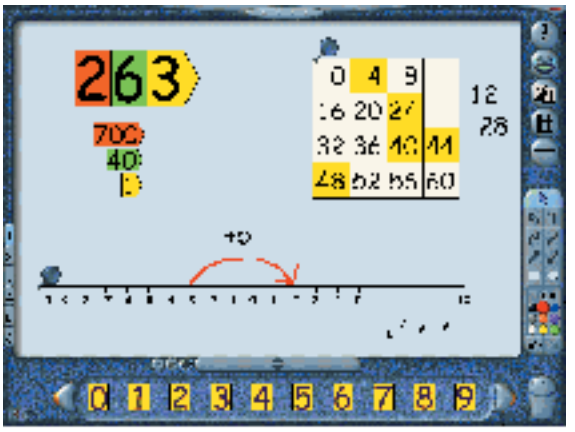
Tel: 01332 346599
Fax: 01332 204357
Email: atm_maths@compuserve.com
URL: http://www.atm.org.uk/



DataSweet, Kudlian Software

Kudlian Software Ltd
8A Nunhold Business Centre
Dark Lane
Hatton
Warwickshire CV35 8XB

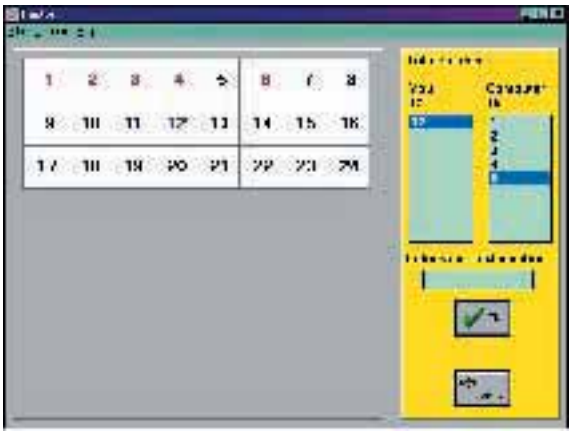
Tel: 01926 842544
Fax: 01926 843537
URL: http://www.kudlian.com/



Easiteach, RM

RM PLC
New Mill House,
183 Milton Park,
ABINGDON,
Oxon OX14 4SE

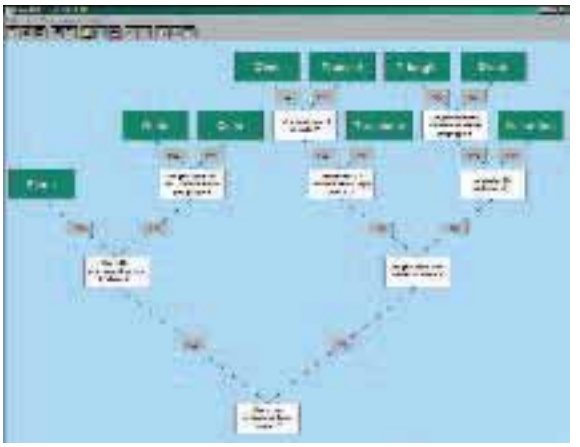
Tel: 01235 826000
Primary Sales: 0870 9086969
Fax: 01235 826999
Email: salesdesk@rm.com
URL: http://www.rm.com/



Factor, SMILE

SMILE Mathematics
Isaac Newton Centre
108A Lancaster Road
London W11 1QS

Tel: 020 7598 4841
Fax: 020 7598 4838
Email: info@smilemathematics.co.uk
URL: http://www.smilemathematics.co.uk/



FlexiTree, Flexible Software

Flexible Software Ltd
PO Box 100
Abingdon
Oxon OX13 6QD

Tel: 01865 391148
Fax: 01865 391030
Email: info@flexible.co.uk
URL: http://www.flexible.co.uk

Freddy Teddy, Topologika

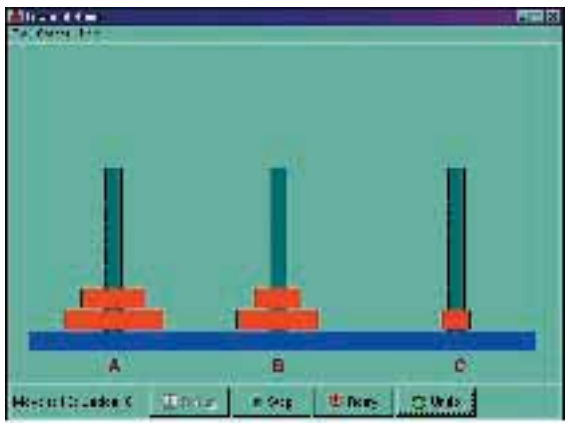
Topologika Software
1 South Harbour
Harbour Village
Penryn
Cornwall TR10 8LR

Tel: 01326 377771
Fax: 01326 376755
Email: sales@topologika.com
URL: http://www.topologika.co.uk/

Frogs, SMILE

SMILE Mathematics
Isaac Newton Centre
108A Lancaster Road
London W11 1QS

Tel: 020 7598 4841
Fax: 020 7598 4838
Email: info@smilemathematics.co.uk
URL: http://www.smilemathematics.co.uk/



Hanoi, SMILE

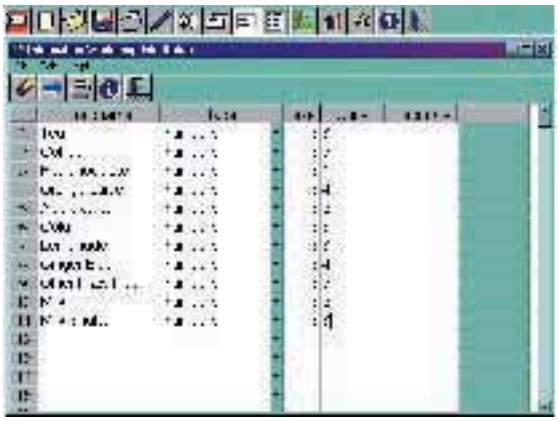
SMILE Mathematics
Isaac Newton Centre
108A Lancaster Road
London W11 1QS

Tel: 020 7598 4841
Fax: 020 7598 4838
Email: info@smilemathematics.co.uk
URL: http://www.smilemathematics.co.uk/

Hutchinsons Multimedia Encyclopaedia, Attica:

Cambridge CD-ROM Ltd
Combs Tannery
Stowmarket
Suffolk IP14 2EN

Tel: 01449 774 658
Fax: 01449 677 600
Email: sales@cambridgecd.co.uk
URL: http://www.cambridgecd.co.uk/index.html



Information Workshop, Black Cat Software

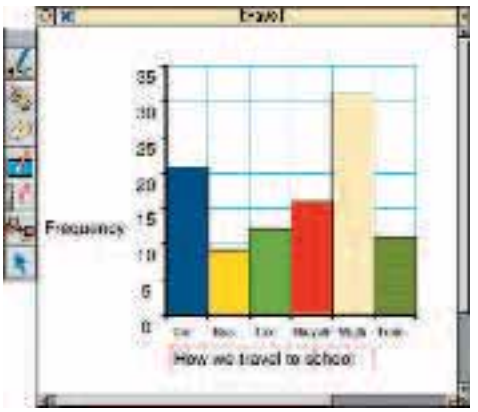
BlackCat Educational Software
Granada Learning
Granada Television
Quay Street
Manchester M60 96A

Tel: 0161 8272979
Fax: 0161 8272966
Email: sales@blackcatsoftware.com
URL: http://www.blackcatsoftware.com/

The Jolly Postman's Party, Dorling Kindersley

Dorling Kindersley Ltd
9 Henrietta Street
London WC2E 8PS

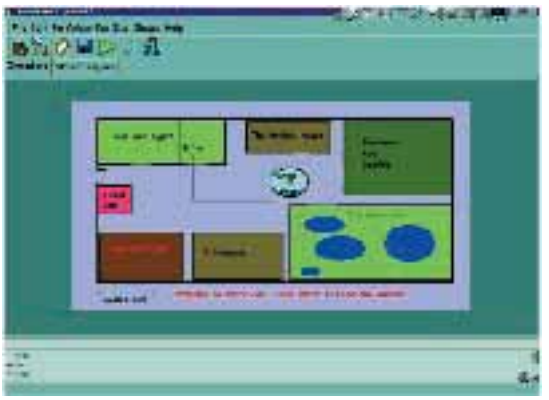
Tel: 020 7836 5411
Fax: 020 7836 7570
URL: http://www.dk.com/uk/



Junior Pinpoint, Longman Logotron

Longman Logotron
124 Cambridge Science Park
Milton Road
Cambridge CB4 0ZS

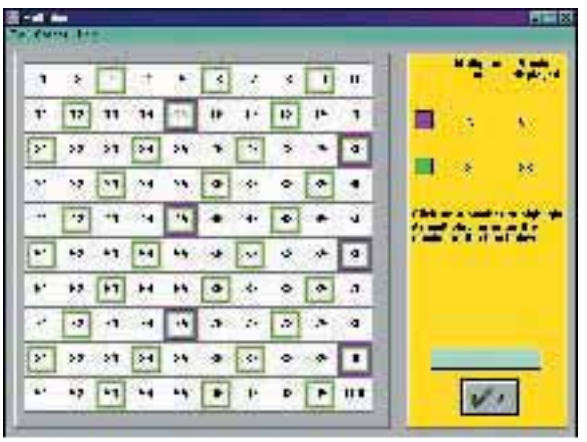
Tel: 01223 425558
Fax: 01223 425349
Email: info@logo.com
support@logo.com
sales@logo.com
URL: http://www.logo.com/



Logo, Lesson Maker, Edutech

REM
Great Western House
Langport
Somerset TA10 9YU

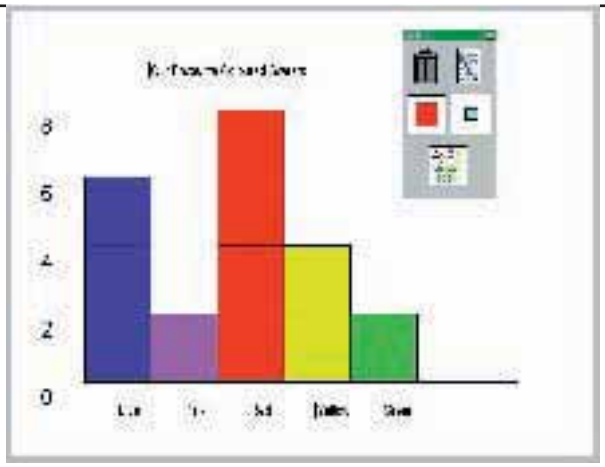
Tel: 01458 254700 44
Fax: 01458 254701
Email: Sales@R-E-M.co.uk
info@R-E-M.co.uk
URL: http://www.r-e-m.co.uk/



Multiples, SMILE

SMILE Mathematics
Isaac Newton Centre
108A Lancaster Road
London W11 1QS

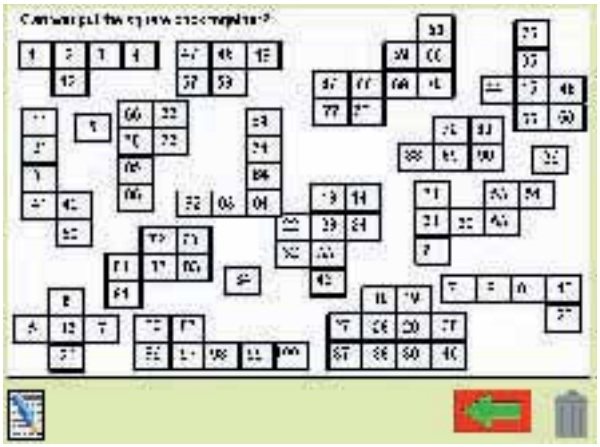
Tel: 020 7598 4841
Fax: 020 7598 4838
Email: info@smilemathematics.co.uk
URL: http://www.smilemathematics.co.uk/



Bar chart: My World
SEMERC/Granada Learning

Granada Learning Ltd
Granada Television
Quay Street
Manchester M60 9EA

Tel: 0161 827 2927
Fax: 0161 827 2966
URL: http://www.granada-learning.co.uk/



Adverntures on a 100 square:
My World of Maths from 7-11
SEMERC/Granada Learning

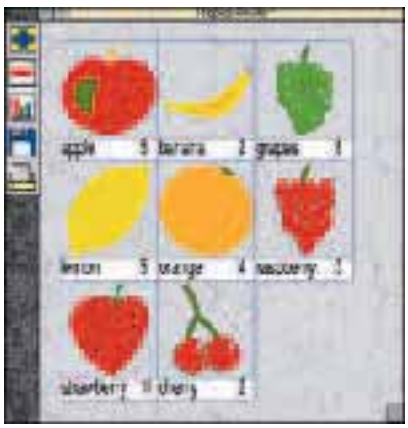
Granada Learning Ltd
Granada Television
Quay Street
Manchester M60 9EA

Tel: 0161 827 2927
Fax: 0161 827 2966
URL: http://www.granada-learning.co.uk/

Number Box, Black Cat Software

BlackCat Educational Software
Granada Learning
Granada Television
Quay Street
Manchester M60 96A

Tel: 0161 8272979
Fax: 0161 8272966
Email: sales@blackcatsoftware.com/
URL: http://www.blackcatsoftware.com/



Picture Point, Longman Logotron

Longman Logotron
124 Cambridge Science Park
Milton Road
Cambridge CB4 0ZS

Tel: 01223 425558
Fax: 01223 425349
Email: info@logo.com
support@logo.com
sales@logo.com
URL: http://www.logo.com/

PIP, Swallow Systems

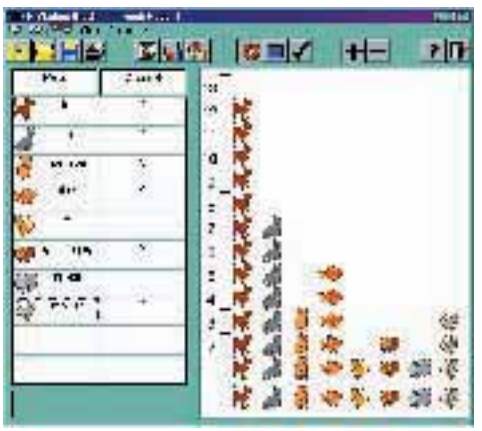
Swallow Systems
134 Cock Lane
High Wycombe
Buckinghamshire HP13 7EA

Tel: 01494 813471
Fax: 01494 813552
Email: sales@swallow.co.uk/
URL: http://www.swallow.co.uk/

Roamer, Valiant Technology

Valiant House
3 Grange Mills
Weir Road
LondonSW12 0NE
United Kingdom.

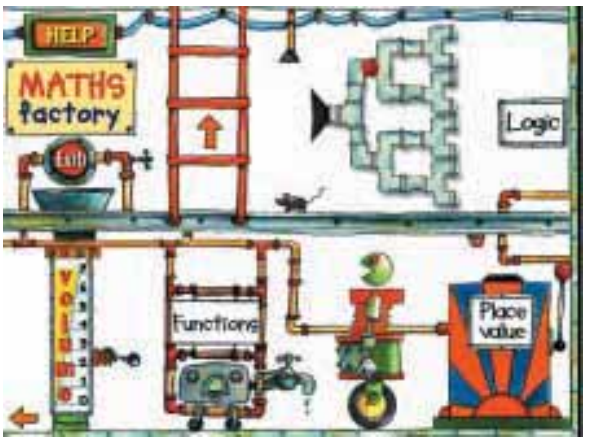
Tel: 020 8673 2233
Fax: 020 8673 6333
Email: info@valiant-technology.com
URL: http://www.valiant-technology.com/



Starting Graph, RM

RM PLC
New Mill House, 183 Milton Park,
Abingdon, Oxon OX14 4SE

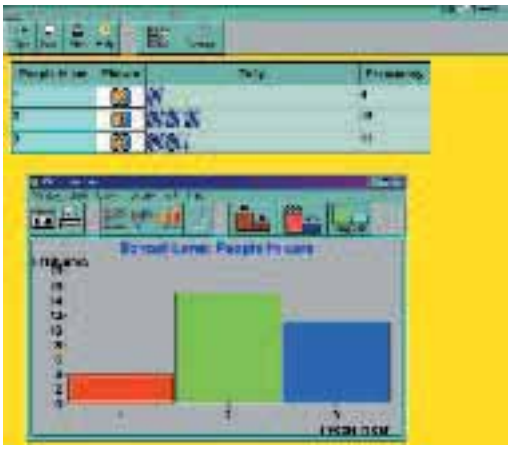
Tel: 01235 826000
Primary Sales: 0870 9086969
Fax: 01235 826999
Email: salesdesk@rm.com
URL: http://www.rm.com/



Steps Maths Factory, Harper Collins

Collins Education
Harper Collins
Westerhill Road
Bishopriggs
Nr Glasgow G64 2QT

Primary Sales: Tel: 0870 0100 441
Fax: 0141 306 3750
Email: education@harpercollins.co.uk
URL: www.collinseducation.com



Survey, SPA

SPA
PO Box 59
Tewkesbury GL20 6AB

Tel: 01684 833700
Fax: 01684 833718
URL: http://www.spasoft.co.uk/

All these addresses and contact details were checked by the National Numeracy Strategy on 15 August 2000.