Key Stage 3
National Strategy

Leading in Learning
Exemplification in mathematics

department for
education and skills
creating opportunity, releasing potential, achieving excellence

Acknowledgement

'Mystery' mathematical problem developed by Kevin Wallis on behalf of Bedfordshire Local Education Authority. Reproduced by permission of the author.

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Introduction

The main source of guidance for teachers involved in the Leading in Learning whole-school initiative is the *Handbook for teachers*. These website materials give additional guidance for teachers of particular subjects, to help them play a full part in the initiative by contributing to 3-lesson cycles devoted to teaching thinking skills.

The first section illustrates the distinctive contribution that the subject can make to the development of pupils' thinking skills. This is the perspective that teachers are asked to adopt when, for an occasional lesson, they subordinate subject concerns for a common focus on a selected National Curriculum thinking skill. An aim of Leading in Learning is that pupils should become aware that these skills are applicable to all areas of learning and in everyday life. Committing a small amount of subject time to serving this aim should benefit learning in the subject as well as learning more generally.

The *Handbook for teachers* includes general guidance on each of the following ten teaching strategies:

Advance organisers
Analogies
Audience and purpose
Classifying
Collective memory
Living graphs and fortune lines
Mysteries
Reading images
Relational diagrams
Summarising

The *Handbook* notes on each strategy usually include one substantial example in a selected subject and brief reference to one or two other subjects. In addition, there is an A3 poster for each strategy that illustrates the 3-lesson cycle with selected subjects. To supplement this, these website materials give brief subject examples for each of the teaching strategies. Whether they describe a general type or are more specific in nature, the examples are intended to stimulate teachers to think of ideas of their own. Some of the strategies are readily used in most subjects but others are more obviously suited to certain subjects. However, imaginative teachers will see possibilities that go beyond the examples given. And as the Leading in Learning initiative gathers pace, LEA networks should provide other rich sources of ideas.

A few resource sheets are provided as appendices, either to illustrate ideas that you can adapt or where a more substantial resource would need to be prepared. These are available in Word format so that you can adapt them to suit your purposes.

Selected references to other publications and resources are included either in the notes for a particular strategy or in a final reference section. **Remember that the *Handbook for teachers* is the main reference source on the Leading in Learning approach to teaching thinking skills lessons and for detailed guidance on each of the ten teaching strategies. These subject examples should be read in conjunction with relevant sections of the *Handbook* and are not intended to stand alone.**

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Thinking skills and mathematics

Mathematics is often thought of as a subject that can develop good thinkers. However, this development needs to be planned for: it does not happen by chance. Thinking skills underpin *using and applying mathematics* and the broad elements of problem solving, communication and reasoning. The *Framework for teaching mathematics: Years 7, 8 and 9* includes a section on the role of thinking skills in the subject (Introduction, pages 20 to 22). The following notes develop some of these points from the perspective of the contribution that teachers of the subject can make to the development of pupils' thinking skills. The Framework's *Supplement of examples* is a rich source of ideas that can provide planned opportunities for developing pupils' thinking skills.

Information-processing skills

These enable pupils to locate and collect relevant information, to sort, classify, sequence, compare and contrast and to analyse part/whole relationships.

The *handling data* strand of mathematics is very explicitly about information processing, but it is important to encompass a wider definition that applies to all strands of the subject. In mathematics, teachers should plan for pupils to:

- *Locate and collect relevant information* – for example, when they extract information from a diagram, table or chart, or when they generate data in a mathematical investigation.
- *Sort, classify and sequence* – for example, when they classify a set of shapes according to their properties or order a set of decimal numbers.
- *Compare and contrast* – for example, when they consider different ways of solving a linear equation or a related table, equation and graph.
- *Analyse part/whole relationships* – for example, when they break a more complex problem down into a sequence of steps, or identify a particular part of a geometrical diagram or other mathematical representation.

Reasoning skills

These enable pupils to give reasons for opinions and actions, to draw inferences and make deductions, to use precise language to explain what they think and to make judgements and decisions informed by reason or evidence.

The centrality of reasoning to the subject is reflected in the fact that it is a key element of the *using and applying mathematics* strand of the National Curriculum. Mathematical reasoning has some very distinctive features and, therefore, has a strong contribution to make to the development of pupils' general reasoning skills. In mathematics, teachers should plan for pupils to:

- *Give reasons for opinions and actions* – for example, when they explain, orally or in writing, why they have reached a particular conclusion to a mathematical question or why they have chosen a particular method.
- *Draw inferences and make deductions* – for example, when they extend a number pattern or start from certain 'givens' in a geometry problem and prove a particular result.

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- *Use precise language to explain what they think* – for example, when they use mathematical notation, symbols and diagrams to set out an ordered solution to a problem.
- *Make judgements and decisions informed by reason or evidence* – for example, when they modify their approach to solving a problem, or decide on the appropriate degree of accuracy for a numerical answer.

Enquiry skills

These enable pupils to ask relevant questions, to pose and define problems, to plan what to do and how to research, to predict outcomes and anticipate consequences and to test conclusions and improve ideas.

Enquiry lies at the heart of mathematics and opportunities to develop particular skills should arise regularly in lessons. An excellent way of developing the whole range of enquiry skills is through mathematical investigations. In mathematics, teachers should plan for pupils to:

- *Ask relevant questions* – for example, when they seek clarification on a point that has been made by either the teacher or another pupil or when they ask themselves, *'Have I got the information I need to solve the problem?'* or *'Is this method the most appropriate to this type of problem?'*.
- *Pose and define problems* – for example, when they suggest an extension to a mathematical problem, ask a supplementary question or devise problems for their neighbour or another group to solve.
- *Plan what to do and how to research* – for example, when they decide what mathematics is needed and set out the steps for solving a problem, or when they follow up a question that requires investigation.
- *Predict outcomes and anticipate consequences* – for example, when they identify a pattern or relationship in a mathematical situation and conjecture about other cases or make a generalisation.
- *Test conclusions and improve ideas* – for example, when they test a generalisation, look for counter-examples or exceptional cases, or develop a more efficient method for solving a problem.

Creative-thinking skills

These enable pupils to generate and extend ideas, to suggest hypotheses, to apply imagination and to look for alternative innovative outcomes.

Like other subjects mathematics has its routines, but there are opportunities to develop creative thinking in all strands of the subject. Often it is the opportunity to do this that brings the subject to life for many pupils. In mathematics lessons, teachers should plan for pupils to:

- *Generate and extend ideas* – for example, when they use web diagrams to illustrate connections between equivalent mathematical statements or to generate related statements.
- *Suggest hypotheses* – for example, when they conjecture about the relationship between two sets of numbers, or when they use the evidence of a data sample to pose a meaningful question worthy of further investigation.

- *Apply imagination* – for example, when they visualise the path of a moving point or how a shape might change as slices are taken from it.
- *Look for alternative innovative outcomes* – for example, when they reach a solution to a non-routine problem by asking questions such as, '*If I knew the answer how would I work back to the question?*' or '*If this angle were to decrease what would happen to the area?*'.

Evaluation skills

These enable pupils to evaluate information, to judge the value of what they read, hear and do, to develop criteria for judging the value of their own and others' work or ideas and to have confidence in their judgements.

Evaluation skills can be developed at all stages in solving a mathematical problem, not just at the end point; for example, considering the appropriateness of a selected method as well as evaluating the solution. In mathematics, teachers should plan for pupils to:

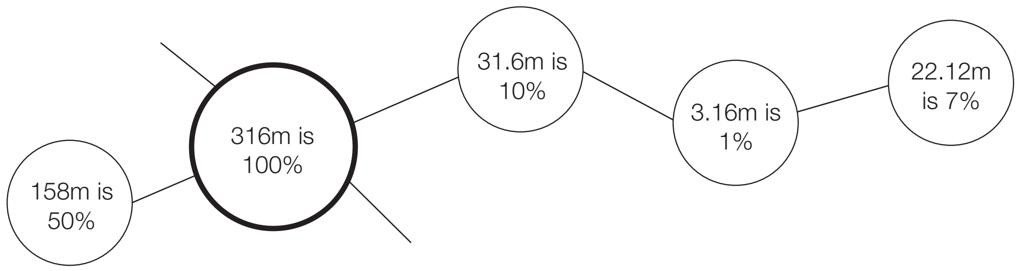
- *Evaluate information* – for example, when they choose between different mathematical representations or move from one representation to another in order to gain a different perspective on a problem.
- *Judge the value of what they read, hear and do* – for example, when they assess whether a method proposed by another pupil is likely to solve a problem, or judge whether an answer is given to an appropriate degree of accuracy.
- *Develop criteria for judging the value of their own and others' work or ideas* – for example, when they compare different approaches to solving a mathematical problem and establish criteria such as appropriateness and efficiency of the method.
- *Have confidence in their judgements* – for example, when they use ways of checking a numerical answer for themselves and are able to confirm its accuracy.

Advance organisers

Graphic organisers in various forms are particularly suited to mathematics because they can be used to map out mathematical relationships that pupils will encounter, and also help them to relate these maps to their existing knowledge. The following examples are taken from the *Interacting with mathematics in Key Stage 3* series of materials from the National Strategy.

Number

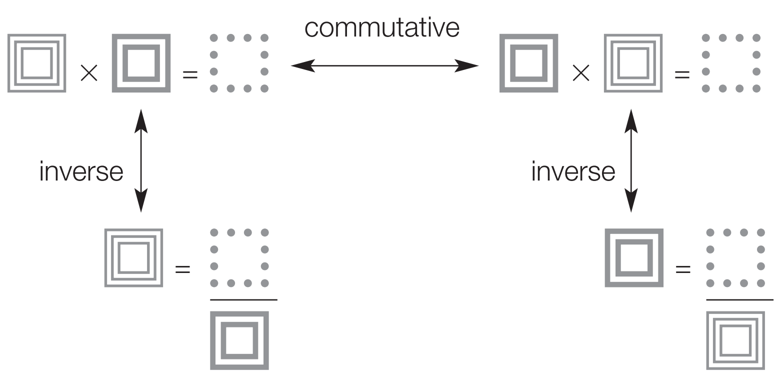
Emma's percentage lesson (*Planning and teaching mathematics 1* (DfES 0439/2002)).



Construct webs of connections between fractions, percentages and decimals recalled by Year 7 pupils from Key Stage 2 (see *Enhancing proportional reasoning* (DfES 0093/2003), Year 7, Fractions and ratio mini-pack, key lesson on page 11), extended to show new connections to be encountered.

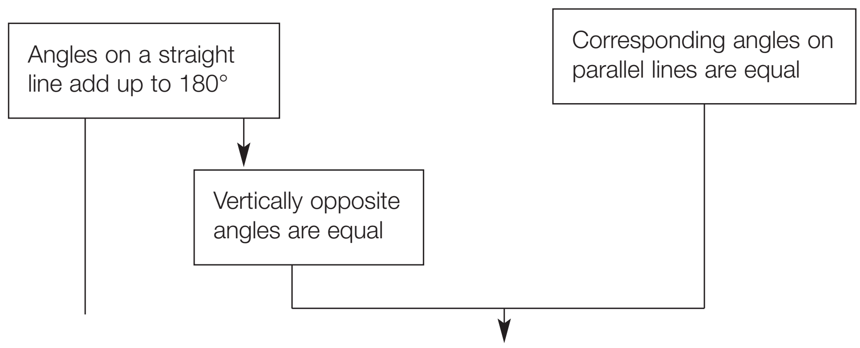
Algebra

Approach algebra as generalised arithmetic, using graphic organisers that illustrate additive and multiplicative relationships (see *Constructing and solving linear equations* (DfES 0063-2004 G), Year 7 booklet, pages 10 and 11). Here is part of a possible organiser – in the shaded boxes pupils might enter numbers, letters or expressions.



Shape, space and measures

Display a decision tree or flow chart, such as a flow chart of logical reasoning – a hierarchy of geometrical facts that can be derived from specified ‘givens’. (See *Interacting with mathematics in Year 9* (DfES 0588/2002), Geometrical reasoning mini-pack, pages 30 and 31.)

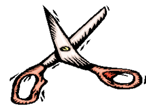
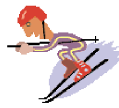
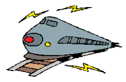


Graphic organisers can also be useful aids to revision. For example, provide a web diagram showing key concepts in a mathematical topic and the connections between them.

Analogies

Analogies are used regularly in mathematics, although not always in an extended way. They often provide images to support pupils in grasping a new idea, understanding a difficult concept or remembering an important fact. The 'Analogies' strategy, therefore, provides an opportunity for teachers and pupils to take a detailed look at mathematical examples and assess their usefulness and validity. They can also be encouraged to question how deeply they understand some key mathematical ideas.

A key resource for this lesson will be a bank of written analogies and possibly some associated images. This might include some or all of the following.

- Vertically opposite angles are like the angles you see in a pair of scissors. 
- Negative gradients are like skiing downhill. 
- Train tracks are like parallel lines. 
- An equation is just like a balance with equal weights on both sides. 
- Finding the mean is like making the heights of skyscrapers in Singapore all the same. 

The use of these analogies and images could then be approached in one or more of the following ways.

- Provide a selection of written analogies for pupils to order according to how useful the 'source' is in helping to describe aspects of the 'target'.
- Provide the images separately and ask pupils to match them to the statements. They could then evaluate the usefulness of the analogies based on the details of the images given (e.g. *Is the skier going downhill the right way?*).
- One or more analogies could be explored in detail and rewritten to be more mathematically accurate, or an alternative could be created (e.g. *Vertically opposite angles are like the angles you see when you criss-cross a pair of rulers*).
- Pupils could create and analyse their own original analogies for mathematical ideas studied in recent units.

The effect of studying a collection of small analogies in this way not only develops thinking skills but also means that analogies used on a future occasion are viewed more carefully and evaluated for their effectiveness.

Some analogies warrant more extended analysis and could be deconstructed in some detail, for example, *'A formula is like a recipe'*.

Audience and purpose

When pupils are given opportunities to communicate ideas and justify reasoning in mathematics, they enhance their understanding of fundamental concepts. The 'Audience and purpose' strategy can be employed to cultivate pupils' awareness of the appropriateness of the form and style of communication which they use in the subject, including the choice of mathematical notation, symbols and diagrams.

For example, pupils could be encouraged to consider how and why the results might differ if asked to 'show your working' when the audience for the writing is:

- a friend who missed the lesson;
- yourself, in the form of revision notes;
- your teacher, who is about to mark your homework;
- an examiner marking a calculator paper;
- an examiner marking a non-calculator paper.

To illustrate another approach, pupils might be given a calculation such as $22 \div 6$ and the following possible answers:

3, 3 remainder 4, 3.66, $3\frac{2}{3}$, 3.666666666, 3.67, 4.

They could then be asked to write a series of different problems where the calculation required is $22 \div 6$ and where each of the seven possible answers would be the appropriate one for the situation. If the lesson is the first in the cycle, pupils could be given word problems and be asked to match them to the answers, considering the criteria they use for the matching. An important element of the lesson would be the discussion about the key criteria used when deciding on a suitable rounding strategy for the result of a calculation.

Other ideas include:

- interpreting data presented in graphs or charts in ways which would be appropriate for a broadsheet newspaper, a tabloid newspaper, a radio news announcer and a mathematics examination paper;
- writing mathematical justifications or proofs in ways which would convince yourself, a friend, a pen-friend and a professor of mathematics;
- developing questionnaires where the wording of a question is deliberately designed to bias the questionnaire to serve the purposes of specified interest groups;
- considering when it is appropriate to plot and when to sketch graphs, and how much detail it is necessary to show on the graph.

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Classifying

Misconceptions in mathematics often arise because pupils have a limited perception of a particular term or concept. Giving them the opportunity to devise their own categories for a collection of such items helps them to explore the scope and meaning of mathematical terms, identify patterns and relationships and avoid the narrowness that can come from simply being given definitions.

When devising examples, allow for different ways of categorising and ensure that there is some ambiguity about how particular cards might be classified in order to stimulate debate. If the activity is presented as a card-sort, items on the cards might be as shown in this table:

Items on the cards	Categories that pupils might devise
Numbers and related diagrams, e.g. linked to ratio and proportion	See *Year 8 to Year 9 transition* lesson on proportional reasoning (website only)
Calculations	Methods used to complete the calculation
Algebraic expressions or equations	Linear and non-linear equations and/or expressions, functions of a single variable, formulae with multiple variables, etc.
Sequences	Ascending, descending, constant difference, etc.
Graphs	Linear, negative gradient, non-linear, goes through the origin, etc.
Geometrical shapes or diagrams, e.g. a set of 2D shapes	One/two lines of symmetry, rotational symmetry, regular shapes, etc.
Word problems	The context, mathematical operations needed to solve the problem, number of steps in the solution, whether a calculator is needed, whether there is sufficient or surplus data, etc.

Many of the terms in the right-hand column are important to the development of mathematical vocabulary and understanding. However, although you need to consider possible classifications when devising the set of cards, it is important not to present these categories to pupils. This more open task provides an opportunity for pupils to develop their understanding. Where cards present items in different forms (e.g. equations and graphs), be aware that providing items to match creates a different (although worthwhile) activity. To ensure that the task stays as an open classification activity, avoid the possibility that the end point of the classification is a simple one-to-one matching of items.

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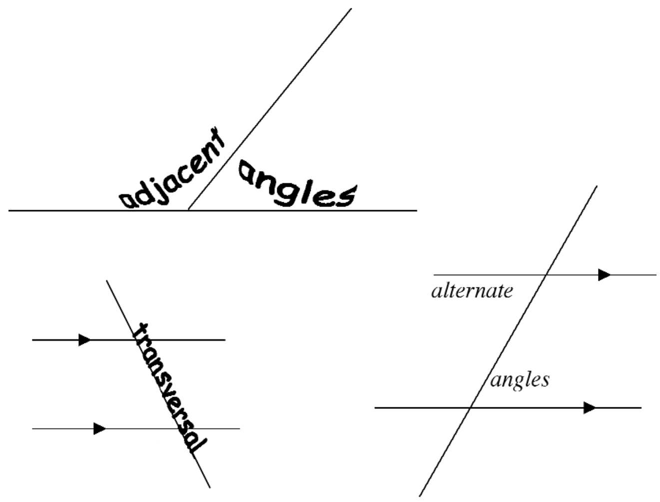
Collective memory

The 'Collective memory' strategy is particularly effective in mathematics because it is a subject that makes extensive use of visual representations, such as geometrical diagrams, graphs, charts, tables and flow charts. In order to reconstruct the image in a short time, pupils have to attend to the mathematical relationships that are represented.

One way of using the strategy to good effect is to illustrate elements of mathematics that pupils need to remember. An example would be a sheet showing mathematical terminology for a given topic, such as the vocabulary of angles. The image could contain several examples such as those shown below:



This general idea could also be applied to other aspects of technical vocabulary or the conventions of marking up a geometric shape.

Another type of example would be an image where there are mathematical connections between different elements of the image. In order to reconstruct the image in the time given, pupils must observe and make use of the connections. A simple illustration of this is the FDPR resource sheet (**Appendix A**, page 20) which can be used to explore the equivalence between fractions, decimals, percentages and ratio. Pupils need to make sense of the colour and shape coding, which forces them to make the connections between equivalent forms. The same structure can be used with various related sets of objects, for example, a set of algebraic equations.

Other ideas include:

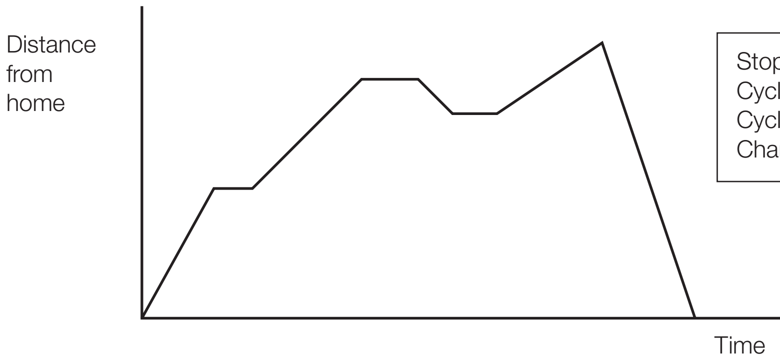
- an equation, table of values and associated graph;
- a matchstick pattern with the associated graph and general form;
- a set of transformations of shapes or functions on a pair of axes;
- a web diagram of algebraic statements, such as 'clouding the picture' (see Key Stage 3 Strategy materials *Constructing and solving linear equations* (DfES 0063-2004 G));
- a data set represented in three or four different forms;
- a mathematical proof and related diagram.

Living graphs and fortune lines

Mathematics is ideally placed to develop thinking skills through the use of the 'Living graphs' strategy because of the variety of contexts where graphical representation is used. This strategy involves more than simply plotting information on a line graph or interpreting information presented graphically. The strategy gets to the heart of pupils' understanding of what the graph does or could show.

The fact that the statements and the line graph can be connected in more than one way requires pupils to justify their decisions, which means that information from the graph is processed more carefully. Pupils may well question the level of ambiguity of the presentation which would be unusual in a mathematics lesson, for example, the lack of a scale on the axes. But thinking about the need for such conventions is a bonus for future mathematics learning.

One way of using this strategy to good effect is to begin with a line graph and a selection of between 10 and 12 'single fact' statements, such as those shown below, to be positioned at the points of the graph they describe.



Stops for lunch
Cycles away from home
Cycles uphill
Changes direction

It is important to allow an open discussion about the possible meaning of points on and sections of the graph. Do not get distracted by detail at this stage. As pupils describe and justify the position of the statements, they learn from one another and use precise language drawn from the context of the line graph. The contexts can be connected to cause/effect statements. Positioning these types of statement before or after key features moves pupils on to 'reading between the lines' of the graph and thinking about what they know as fact from the graph and what is 'informed guesswork'.

Other contexts can be tracked against time. For example:

- the total savings of an individual (leaves home, buys a house, etc.);
- house prices in a particular area (new rail link completed, number of houses for rent doubles, local school gets a good Ofsted report, etc.);
- number of visitors to a tourist location (beach is declared 'blue flag', leisure centre is built, etc.);
- the record sales of winner of a talent show (releases first record, gets married, completes tour, etc.).

Once familiar with the task, pupils can create a graph from a selection of statements. This requires a little more creative thinking but engages pupils with the process of graphically representing key features on a line graph, rather than dealing with isolated facts through simply plotting points.

Mysteries

In a 'Mystery' pupils are asked to find an answer to a single question, set in a context described through mathematical evidence. For example:

- *Who killed Lord Mortimer?* (speed, distance, time, conversions, etc.)
- *Was the election rigged?* (charts, tables, averages, probabilities, etc.)
- *Who won the cycle race?* (tables, line graphs, speeds, times, etc.)
- *Who is the richest?* (tables, charts, conversions, averages, etc.)

There is no single correct answer and not all of the mathematical information is relevant. Such a mystery can take some time to prepare but is a resource which can be used repeatedly and always gets an excellent response from pupils. In addition, it is sometimes possible to design the framework of a mystery (the question and type of evidence) and then vary the mathematical detail (the clues) in a way which adjusts the level of challenge to suit different groups.

The following mystery is provided to give an idea of the strategy.

'A murder has been committed at Castle Pentagon. Lord Mortimer's body was found in the main hallway of the castle at 7pm on Saturday 31 October. Scotland Yard has shortlisted five prime suspects and detectives are now seeking the help of a team of mathematicians to sort out the alibis. YOU are these mathematicians. Sort out the information; formulate a solution; justify your reasoning. Who did kill Lord Mortimer?'

The basic facts given are that there are five gates to the Castle (the N, S, E, W and NE gates), and six routes which lead to the five gates (the bridleway, the B415, the A7, the dirt track, Hangman's Footpath and the B666).

In addition, there is a set of cards with information on several characters. For each of these possible suspects, pupils are guided to think about the speed, time and distance of their journeys to the Castle. Did they have enough time? Could they travel fast enough? Were they too far away?

Text suitable for making into a set of cards is presented on the 'Mysteries' resource sheet (**Appendix B**, page 21), for example, *'Melissa Killjoy stopped to repair a puncture at around 2:15pm.'*

This mystery was developed by a group of teachers in Bedfordshire and can be found in its full form along with a lesson plan on the LEA website at **www.schools.bedfordshire.gov.uk/numeracy/index.html**.

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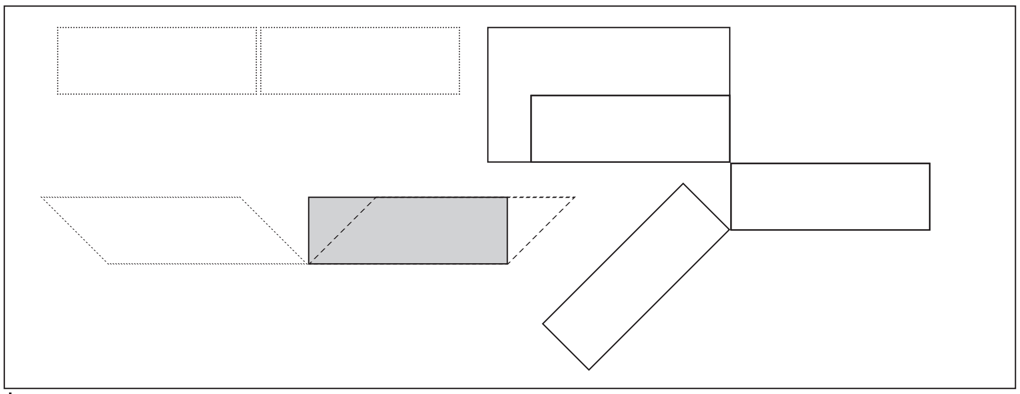
Reading images

In mathematics an ‘image’ could constitute any of the following:

- a photograph of a real scene;
- a pattern, e.g. from tiling, art, textiles, natural world;
- a graph or chart, perhaps with a table or the related function;
- a set of plans or scale drawings;
- a mathematical diagram or set of equations.

It is crucial that the ‘reading’ of the image is not driven by teacher-led questions but open to the interpretation of the groups of pupils. In this respect it is quite different from the usual use of diagrams/images as a context for a set of mathematical questions.

An image may be used to draw together the learning which has taken place in a particular unit of work so that the general focus of the ‘reading’ will be clear. Alternatively, the image may help to produce an advance organiser at the start of a unit, as pupils bring together all of their present knowledge on, for instance, ratio and proportion.



Consider the image above. It could be used in a unit on ratio and proportion or a unit on transformations, and stimulate quite different responses from pupils in the two different contexts. For example, the sort of titles which pupils choose might be: ‘Ratio of lengths’; ‘Length: length, area: area’; ‘Similar shapes?’; ‘Which transformation?’ or ‘What is the start-point?’.

One way of modelling the start of the discussion is to ‘say what you see’. Although this may give a literal meaning to the image, verbalising this meaning will promote further insights. Follow this by ‘reading between the lines’ of the image, as this promotes greater insight and higher-level thinking.

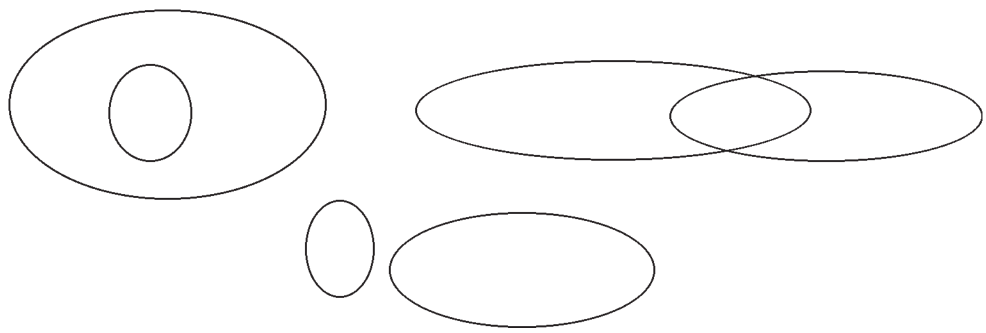
Another simple but effective example is illustrated by the resource sheet which gives images related to angle bisection, but presented without title or verbal instructions and not in a plausible sequence (**Appendix C**, page 22).

Relational diagrams

The 'Relational diagrams' strategy is particularly effective in mathematics. It provides opportunities for pupils to make extensive use of vocabulary and develop a thorough understanding of mathematical meanings. It requires pupils given a list of words to make connections between the words and identify similarities and differences.

As described in the Leading in Learning *Handbook for teachers*, this strategy engages pupils with a list of between two and five associated mathematical nouns. For example, a list might include some or all of: *square numbers, even numbers*, *integers*, *primes* and *powers of ten*.

Relational diagrams using only two of the nouns from the list can still provide an interesting task. *Even numbers* and *integers* would generate the first 'all' diagram. *Even numbers* and *square numbers* would generate the second 'some' diagram. Are pupils likely to produce the third 'none' diagram possible for a pair of nouns from this collection?



To extend the task, pupils could be challenged to draw relational diagrams to represent the relationships between more of the nouns.

Other examples of lists might be:

- *square numbers, integers, triangular numbers, fractions, odd numbers;*
- *expressions, factorised expressions, quadratics, linear equations, expanded equations;*
- *common factor of a and b, highest common factor of a and b, common multiple of a and b, lowest common multiple of a and b, numbers greater than a, numbers less than a* (a and b the same positive whole numbers throughout);
- *triangle, isosceles shape, regular shape, kite, trapezium.*

Pupils' current body of knowledge will limit the way in which the relationships are presented, so the choice of nouns is crucial. They should be familiar but challenging to illustrate in terms of interrelationships. The picture will provide good diagnostic information and an opportunity to respond to misconceptions in future teaching. Do not be tempted to correct interpretations; pupils often do this for themselves as the lesson unfolds.

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Summarising

This may seem an unusual strategy to use in mathematics but with a little thought it is possible to see that mathematicians summarise all the time.

Consider the following solution:

$$\frac{-6}{x} = x - 5$$

$$x^2 - 5x + 6 = 0$$

$$x = 2, \quad x = 3$$

The above is summarised on the basis of the mental processes which have been performed.

Thus presenting very detailed step-by-step solutions allows pupils to summarise them on the basis of the mental processes which they would be able to perform.

Consider the stages involved in gradually processing a set of raw data. We could begin with a list of ordered data, moving to a stem and leaf diagram, to a frequency table and to a bar chart. In this process we lose detail but gain visual simplicity and thus bring into focus key aspects of the data.

Consider the steps we might take to solve a mathematical problem which is expressed in words. For example: *'How much underlay is required for an entire apartment?' The underlay is sold in square metres and costs £2.75 per sq m. The apartment consists of a hallway, bathroom, kitchen/diner, living room and one bedroom. The height of all rooms is 2.3m. The width of the hall is 1.4m and the length is 6.5m. The bathroom is 3m square, the kitchen/diner is 3.2m wide and 4.5m long with an alcove at one side measuring 0.5m by 1.6m. The living room and bedroom are both complex shapes but the longest length is 3.6m and the widest part measures 3m*.

To begin this problem we follow steps which are closely aligned to the five steps for summarising.

- **Delete unwanted details:** the name and height of each room, the price of the underlay.
- **Delete information which is repeated in some way:** the names of the rooms.
- **Replace some detail with a simpler or more general form:** assume rooms to be rectangular, neglect small alcoves.
- **Select the key question which is posed:** how much underlay is required?
- **Check that we have sufficient detail to make sense of the problem and solve it.**

When we draw a diagram of a mathematical situation we choose to feature certain details and neglect others, for example, a bearings problem concerning two ships is reduced to a pair of points, lines and angles. We synthesise information to give the main gist in order to solve the problem.

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References

Leading in Learning *Handbook for teachers* (DfES 0035-2005)

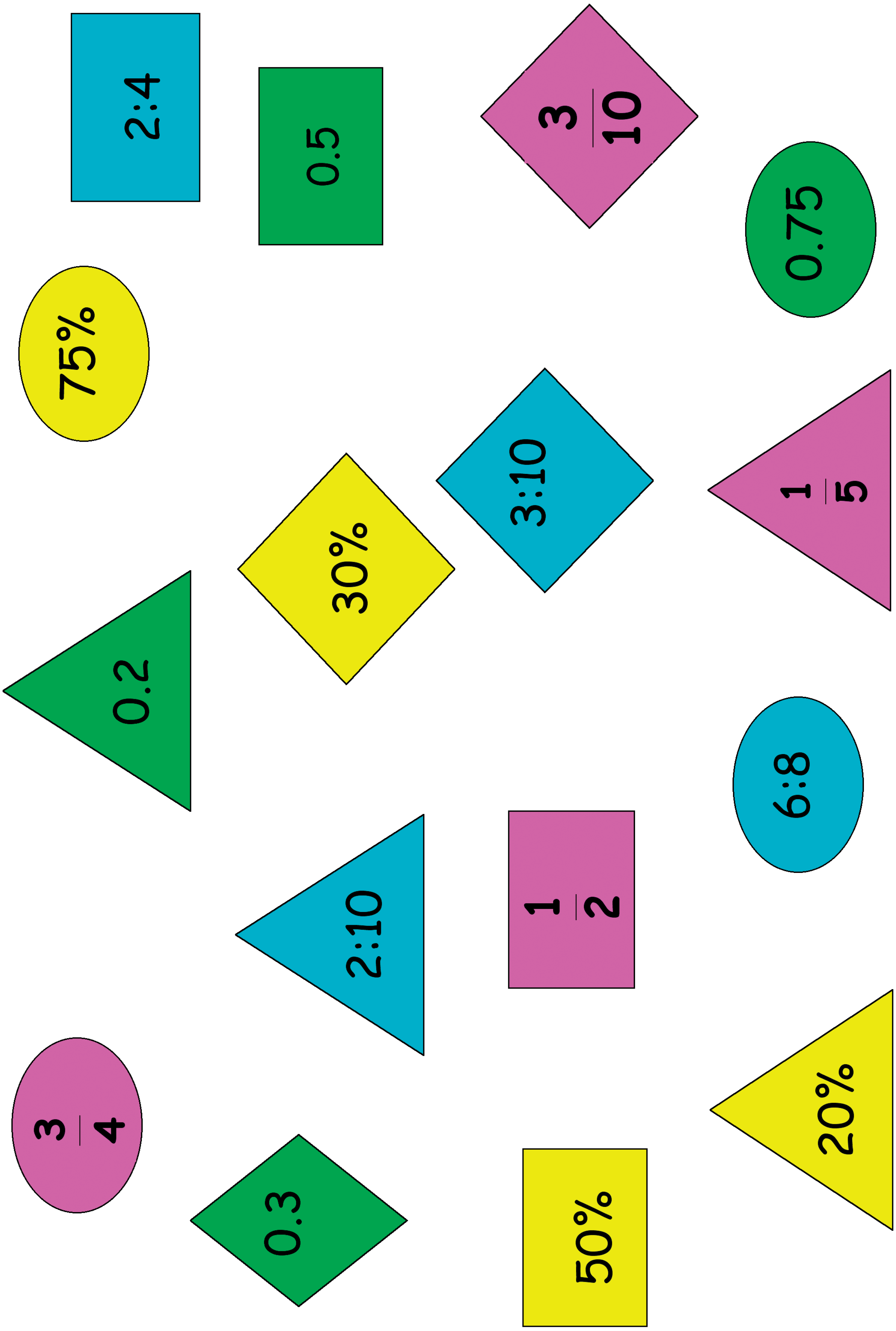
Framework for teaching mathematics: Years 7, 8 and 9 (DfEE 0020/2001)

Interacting with mathematics in Key Stage 3 series of materials:

- *Planning and teaching mathematics 1* (DfES 0439/2002)
- *Enhancing proportional reasoning* (DfES 0093/2003)
- *Constructing and solving linear equations* (DfES 0063-2004)
- *Interacting with mathematics in Year 9* (DfES 0588/2002)

Resources

Collective memory: Appendix A



Mysteries: Appendix B

Who killed Lord Mortimer?

Here is a set of cards for a mathematics mystery. Full details can be found at **www.schools.bedfordshire.gov.uk/numeracy/index.html**. Reproduced by permission of the author.

When the body was found at 7pm it had a temperature of 30°C.	Given the ambient temperature of 15°C, the body would have cooled at a rate of 2°C per hour.	Normal body temperature is 38°C.
Melissa Killjoy was seen at 2pm riding her bicycle. She was on the bridleway, 5 miles from the Castle.	The bridleway leads directly to the Castle's north entrance.	Melissa Killjoy stopped to repair a puncture at around 2:15pm.
It takes approximately 1 hour to cycle 10 miles.	Charlotte Deadworthy was seen on her moped on the B415, 10 miles from the Castle.	The B415 passes the east entrance to the Castle.
The Castle's east entrance was blocked between 2:30pm and 2:45pm, as cows were herded for milking.	The average speed of a moped is 30mph.	Charlotte Deadworthy was out on her moped between 2:30pm and 3:30pm.
At 2pm James Dunnit stopped for petrol in his Ferrari at Plotter's garage on the A7.	Plotter's garage is approximately 80 miles from Castle Pentagon.	Castle Pentagon's south entrance is 2 minutes away from the A7.
James Dunnit only had enough money to fill half a tank of petrol.	A Ferrari can easily reach speeds of 110kmph on the A7.	Malcolm Strange was seen ploughing his fields in Suspect Village at around 2:30pm.
A dirt track links the farm at Suspect Village to the west entrance of Castle Pentagon.	Suspect Village is around 2 miles from the Castle.	The top speed of Malcolm Strange's tractor is 10mph.
Mr and Mrs Bloodshed are seen walking with their dog on Hangman's Footpath at around 3pm.	Hangman's Footpath is 2km long and leads to the north-east entrance of Castle Pentagon.	Average walking speed is 1m/s.
Mr and Mrs Bloodshed's dog is seen at the north-east gate at around 3:15pm.	At 2pm the Macabre Family stop off at the Culprit service station on the M1.	The Culprit service station has a back entrance, which leads onto the B666.
The B666 leads to the Castle's west entrance, which is 10 miles from Culprit Services.	The Macabre family are towing a caravan. They have a top speed of 50mph.	Mrs Macabre and the children are seen eating in the service station restaurant. Mr Macabre says he was taking a nap in the car.

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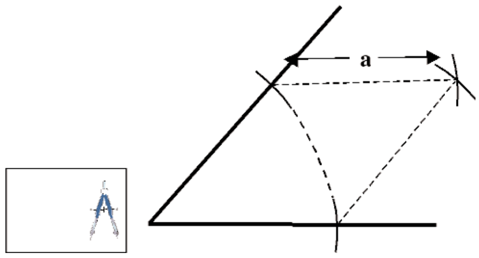
Reading images: Appendix C

C



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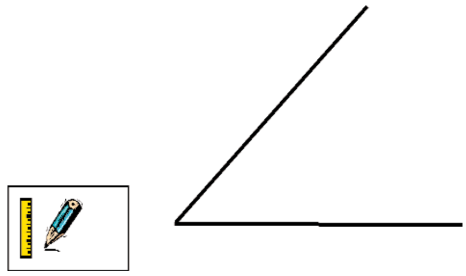

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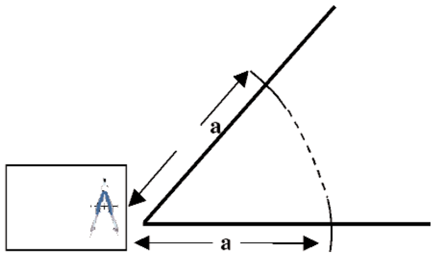
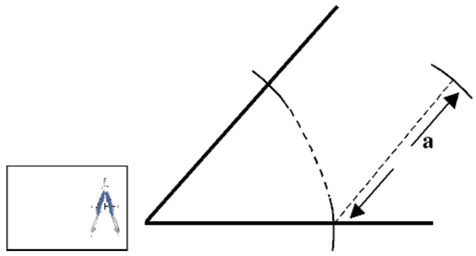


A



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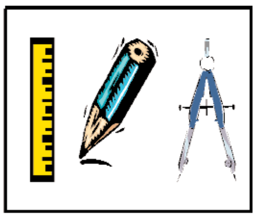
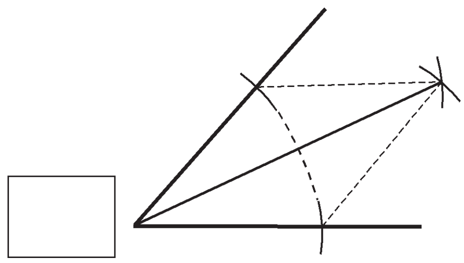


B



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