Embedding ICT @ Secondary

Use of interactive whiteboards in mathematics

department for education and skills
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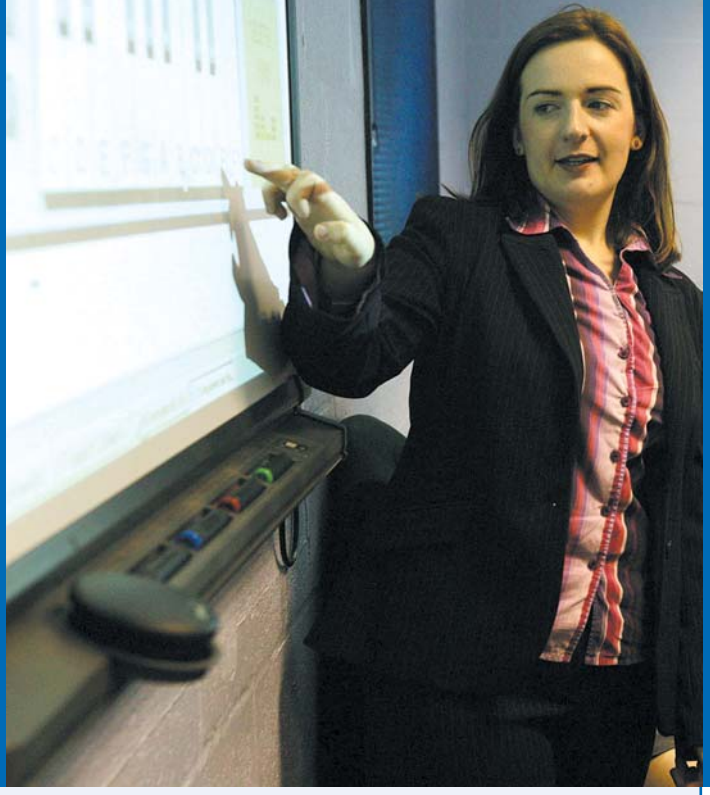
Key Stage 3
National Strategy

Becta
British Educational Communications and Technology Agency

Contents:
Use of interactive whiteboards in mathematics



Section 1: Getting started

1.1 Introduction

Your interactive whiteboard has arrived in your classroom. You have had some technical training from the whiteboard's suppliers and you are ready to go. This booklet aims to help you take the first steps in using the whiteboard to support your teaching of mathematics. You should find enough support here to get started, after which, we hope, you will soon find using the whiteboard both easy and exciting.

'I was really excited when I first realised I was getting an interactive whiteboard in my classroom. However, it was rather a challenge quite knowing where to start. The company that sold the whiteboard gave us some really motivating training and I became very excited about the possibilities, but I still wanted some further support to use it effectively in lessons to improve my teaching.

'For the first few weeks I just used it in the same way as my old whiteboard – for writing on in handwriting. But I knew that I could save what I had written and I slowly started to revisit work we had already done. I could see that I could do so much more with the interactive whiteboard. A group of us who had the boards met and the people who had had them longest talked about them and demonstrated what they could do. This made me much more confident about trying different things.

'I started to add pictures and text and found some great resources online. I also started to use some CD-ROMs that we had in the department and in the library. I am feeling my way gradually and I can see the long-term benefits in using this technology.'

1.2 What is an interactive whiteboard?

An interactive whiteboard is simply a surface onto which a computer screen can be displayed, via a projector. It is touch-sensitive and lets you use a pen on it (or in some cases, a finger) to act like a mouse, controlling the computer from the board itself. Changes made to information projected onto the whiteboard are transferred to the computer and can be saved and retrieved in future lessons. Everything that can be displayed on a computer can be projected onto the whiteboard and, if the computer is linked to speakers and a DVD or video player, multimedia resources can be incorporated too. If the board is connected to the Internet, teachers can have immediate access to appropriate websites to enhance work in the lesson.

There are two main types of interactive whiteboard. Hard boards have a hard magnetic surface behind the screen and need special pens to write on them. Soft boards have a tough membrane on the surface which can be written on with a finger or a special pen. Most interactive whiteboards are supplied with specific software tools to exploit the potential of the board.

The basics

The best way to understand how a whiteboard works is simply to find one and to have a try. You will find that it is easy to control the computer from the board itself. The most important point to understand is that anything that works on the computer will work on the interactive whiteboard too.

Certain items of equipment are needed to use the different features of interactive whiteboards.

- **Essential pieces of equipment are**: the interactive whiteboard and supplied software, computer and data projector.

- **You should also consider**: additional software, speakers, multimedia, remote input devices such as a keyboard, gyromouse or voting devices.

Other issues that need to be taken into account are:

- Installation
- Maintenance/warranty
- Security
- Networking to the school network and the Internet

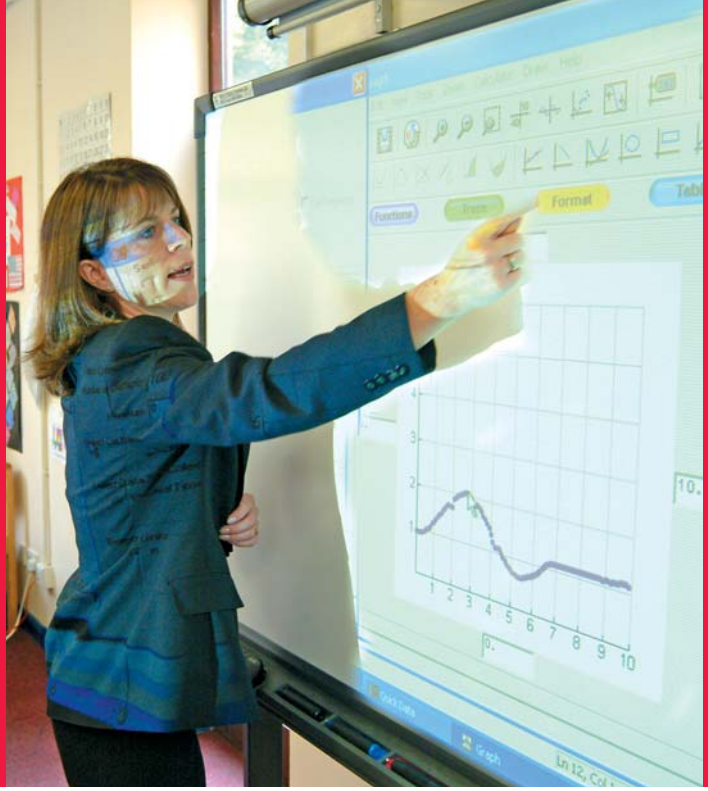
It is important to remember that there are likely to be additional costs that need to be allowed for when using an interactive whiteboard. For example, replacement projector bulbs are also needed. These are expensive but do last a long time.

For further advice on these issues and procurement visit **www.whiteboards.becta.org.uk**

'When we first looked into getting an interactive whiteboard for our department, we realised that we needed to take into account not just the costs of the board itself, but also the cost of the computer, the projector, speakers and training for staff. We were also really keen to be linked to the Internet but the classroom we wanted to use wasn't wired up for that, so it took a few months to sort out.

'It all seemed to be going well until the bulb in the projector blew. We didn't have any in stock and one had to be ordered. It took a couple of weeks to arrive and it was quite expensive. Those of us who had become used to using the whiteboard felt lost without it.'

Section 2: Why use an interactive whiteboard?



Interactive whiteboards have the potential to improve teaching and learning in a variety of ways. In this section, we will focus on three key areas:

1. Presentation, demonstration and modelling
How the use of appropriate software and resources in combination with the interactive whiteboard can improve understanding of new concepts.

2. Actively engaging pupils
How pupils' motivation and involvement in a lesson can be increased through the use of the interactive whiteboard.

3. Improving the pace and flow of lessons
How the use of an interactive whiteboard can improve planning, pace and flow in lessons.

2.1 Presentation, demonstration and modelling

An interactive whiteboard is a valuable tool for whole-class teaching. It is an outstanding visual resource that can help teachers to present lessons in lively and engaging ways. It allows information to be presented using a wide range of resources, which can then be annotated by teachers and pupils to clarify and refine understanding. It can facilitate explanations of models by both teachers and pupils and contribute to an understanding of what happens to a model if a variable or rule is altered.

Teachers can use the board to demonstrate and present ideas in exciting and dynamic ways. The boards also allow pupils to interact with the new learning that is being demonstrated, as well as providing a valuable tool for teachers to model abstract ideas and concepts. Teachers can change what they put on the board easily, or move an object to a different place, making new connections. They will be thinking aloud as they carry out the process, making what they are doing transparent to pupils. They will gradually involve pupils, who can then add their own ideas to the board.

2.2 Active engagement

Evidence suggests that the interactive whiteboard 'increases enjoyment of lessons for both students and teachers through more varied and dynamic use of resources, with associated gains in motivation' (Levy 2002).

The careful use of a whiteboard can support teachers in effective questioning. Well-judged questioning, which is aimed at pupils refining their ideas and posing new questions, helps them to deepen their understanding of the concept or idea.

It can provide a focus and impetus to class discussions managed by the teacher and give stimulus to small group work. The whiteboard provides an engaging focal point in the classroom. It also supports a good pace in teaching, as all the resources are prepared in advance of the lesson and are instantly available.

areas highlighted and colour added. In addition, sections of text, pictures or diagrams can be concealed then revealed at key points during the lesson. This is done with teachers or pupils at the front of the room and becomes the focal point of the class' attention.

2.3 Improving the pace and flow of lessons

The use of interactive whiteboards allows for the creative and seamless use of materials, as lessons or topics can be structured around a single file. Files or pages can be prepared in advance and used to link to other resources deployed in the lesson. Teachers say that preparing lessons around a single file helps with planning and assists the flow of the lesson. It also allows for reflection after the lesson.

'It is very useful as a means of planning on the basis of past teaching and, following review with colleagues, we can share, adapt and develop according to needs' (teacher quoted in Glover and Miller 2001).

Objects and text can be moved around easily using the whiteboard, diagrams labelled, text, pictures and diagrams annotated, key

Pre-preparing text, charts, diagrams, pictures, music, maps, subject-specific CD-ROMs as well as including hyperlinks to multimedia files and the Internet can give lessons a crisp pace, as no time is wasted writing on the board or moving between keyboard and screen. These pre-prepared resources can be annotated on screen if required, using the handwriting tool, and saved for future use. Files from previous lessons can then be recalled to help with reinforcing previous learning.

These strategies can also engender a greater sense of involvement and engagement in the lesson in the pupils. The work they do on the board can be saved and referred to later. Flip charts or pages can be stored at the side of the board as thumbnails and the teacher can move backwards to an earlier section, if need be, to reinforce learning for the whole class or a small group. Pupils who are unclear about what has been taught can refer back to teaching points from earlier parts of the lesson.

2.4 What the research says

These benefits of whiteboard use have been highlighted in Becta's publication, *Getting the Most from Your Interactive Whiteboard: A Guide for Secondary Schools*

General benefits

- versatility, with applications for all ages across the curriculum (*Smith A 1999*)
- increases teaching time by allowing teachers to present web-based and other resources more efficiently (*Walker 2003*)
- more opportunities for interaction and discussion in the classroom, especially compared to other ICT (*Gerard et al 1999*)
- increases enjoyment of lessons for both students and teachers through more varied and dynamic use of resources, with associated gains in motivation (*Levy 2002*).

Benefits for teachers

- enables teachers to integrate ICT into their lessons while teaching from the front of the class (*Smith H 2001*)
- encourages spontaneity and flexibility, allowing teachers to draw on and annotate a wide range of web-based resources (*Kennewell 2001*)
- enables teachers to save and print what is on the board, including any notes made during the lesson, reducing duplication of effort and facilitating revision (*Walker 2002*)
- allows teachers to share and re-use materials, reducing workloads (*Glover & Miller 2001*)
- widely reported to be easy to use, particularly compared with using a computer in whole-class teaching (*Smith H 2001*)
- inspires teachers to change their pedagogy and use more ICT, encouraging professional development (*Smith A 1999*).

Benefits for students

- increases enjoyment and motivation
- greater opportunities for participation and collaboration, developing students' personal and social skills (*Levy 2002*)
- reduces the need for note-taking through the capacity to save and print what appears on the board
- students are able to cope with more complex concepts as a result of clearer, more efficient and more dynamic presentation (*Smith H 2001*)
- different learning styles can be accommodated as teachers can call on a variety of resources to suit particular needs (*Bell 2002*)
- enables students to be more creative in presentations to their classmates, increasing self-confidence (*Levy 2002*)
- students do not have to use a keyboard to engage with the technology, increasing access for younger children and students with disabilities (*Goodison 2002*).

Factors for effective use

- sufficient access to whiteboards so teachers are able to gain confidence and embed their use in their teaching (*Levy 2002*)
- use of whiteboards by students as well as teachers (*Kennewell 2001*)
- provision of training appropriate to the individual needs of teacher (*Levy 2002*)
- investment of time by teachers to become confident users and build up a range of resources to use in their teaching (*Glover & Miller 2001*)
- sharing of ideas and resources among teachers (*Levy 2002*)
- positioning the whiteboards in the classroom to avoid sunlight and obstructions between the projector and the board (*Smith H 2001*)
- a high level of reliability and technical support to minimise problems when they occur (*Levy 2002*).

Section 3: Where do I go from here?

3.1 Planning to teach with an interactive whiteboard

Interactive whiteboards offer far greater potential for teaching than simply being used as electronic chalkboards. They can also enhance lessons more than a data projector and a computer used on their own. Using an interactive whiteboard to its full potential requires planning, and this will take time. However, lessons created for the whiteboard can be used again, with or without adaptations, which actually saves time in the long run. Whiteboards also allow for lessons to be improved and refined based on practice, and they are likely to benefit by being carefully structured to take full advantage of the whiteboard technology.

Interactive whiteboards offer a wide range of advantages in the teaching of all subjects. Many teachers say whiteboards have led them to plan collaboratively with other members of their departments, which has had the effect not only of saving time but also of improving the overall quality of what is produced.

Teachers interviewed also say that they feel their planning has improved because of the way the interactive whiteboard software allows them to structure their lessons before they teach them. The fact that lessons can be saved, complete with notes, and then easily altered, allows for improvement and refinement before the topic is taught again. Teachers can also create libraries of resources which build up as they use the whiteboard.

The range of content available for use with the whiteboard means that students sometimes grasp new ideas and concepts more quickly. This is partly due to the visual nature of the presentation, and partly because whiteboards offer ways of actively engaging pupils in activities. Teachers who have been using the boards for some time feel that the quality of some of their lessons has improved too.

It is not possible to say categorically that pupils' results will improve through the use of interactive whiteboards, but many teachers using them note that pupils are more engaged, more interested and more motivated. They discuss topics more and they seem to remember things better.

'I guess it's almost impossible to say whether your teaching improves with a whiteboard and how far a pupil's success is attributable to the use of the board, but I know that I have seen improvements in my students' work.

'Their enthusiasm has definitely increased and I think that is because I am able to find more interesting and relevant resources. Let's face it, they watch TV and play with their computers at home, so I can understand their lack of interest in some of the text books we have.

'I was really worried at one point because I realised that last term we'd written a lot less down than we would normally do. There seemed to be more talk in class, but talk about what we were doing and what was on the board eg "What if we did this...?" or "How would it change if we did that?" I was still concerned about the lack of written work, but when the end-of-module test results came back they were actually better than they had been the year before. Pupils seemed to find it easier to remember what we did in class. Well, that has to be a bonus!'"

In summary, using an interactive whiteboard has the following advantages:

- The lesson can be pre-prepared, which can contribute to a brisker pace and more time for meaningful discussion.
- Links can be created from one file to another – for example, to a sound or video file or an Internet page. This saves time looking for another resource and keeps the lesson flowing smoothly. It allows for the integration of a variety of media, facilitating audio and visual tasks. This is particularly important in languages, where teachers are very aware of the value of pupils being able to see and hear language simultaneously.
- Structuring the presentation of new material around a series of pages demands a logical step-by-step approach that can enhance and enrich lesson planning.
- Files can be saved to the school network at the end of a lesson for pupils to access later. The files can be saved in their original format or as they appear at the end of the lesson, complete with annotations and final tasks. These can be a useful reference point for both teacher and pupils, to be drawn upon later for revision purposes.

It is important to realise that using an interactive whiteboard on its own will not provide any magic solutions to problems. Nor should teachers feel obliged to use the whiteboard in every part of a lesson, or indeed in every lesson. Sometimes the whiteboard might only be used for a starter or a plenary. As with any resource, its use will have most impact when it is used appropriately to enhance teaching and learning.

Teachers need to understand the generic software that comes with the whiteboard and its potential for helping them to create curriculum resources. They also need to identify subject-specific resources that can enhance the work they are doing on the whiteboard; eLCs (eLearning Credits) are likely to be available to help them purchase these resources where necessary.

3.2 Using software tools

In the introduction, we mention that an interactive whiteboard is, in part, a display board for your computer. This means that all the resources which are on your computer can be displayed on the interactive whiteboard.

This gives you the scope to use resources such as:

- Presentation software
- Word-processing software
- CD-ROMs
- The Internet
- Image files (eg photographs, drawings, diagrams, screenshots)

- Movie files (eg sections of video from television programs, VHS video cassettes or files from a digital movie camera)
- Links to sound files (such as sections from cassettes or radio or recorded by a pupil or member of the teaching staff). Any sound included in a CD-ROM or Internet page will also play, providing that speakers are attached.
- Whiteboard software, which has the additional advantage over presentation software that items can be moved on the screen.
- Subject-specific software.

It is probable that lessons will involve a variety of these resources and that the teacher will pick and choose from what is available. Many of the resources listed above will take advantage of the features available on a computer, eg colour, movement and sound, all of which are more difficult (but not impossible) to achieve in a traditional lesson.

It is probably the ease with which such features can be deployed that makes pupils say that the resources used on an interactive whiteboard are generally more 'exciting' than those used in 'traditional' lessons. However, teachers do often have to search around to find appropriate resources. Look at the **Further links and references** section of this publication for some ideas to help with finding suitable materials.

In addition, most interactive whiteboards come with a useful range of generic functions which are likely to include some of the following:

Whiteboard function	Contribution to teaching and learning
Colour	The range of colours available on an interactive whiteboard allows teachers to use colour to indicate important areas for focus, to link similar ideas or to differentiate between ideas, or to demonstrate a process using colour. Examples of this might be a chloropleth map in geography or a diagram of the digestive system in biology.
Annotations on the screen	These are useful for modelling thinking and for adding information, questions and ideas to text, diagrams or pictures on screen. Annotations can be saved, referred to again or printed off for pupils to use.
Inclusion of sound and video clips	This can significantly enhance learning in a lesson. The technology also allows screens from video clips to be captured and displayed as still images for discussion and annotation.
Drag and drop	This helps pupils to group concepts, identify advantages and disadvantages, identify similarities and differences, and label maps, pictures, diagrams, equipment for an experiment and much more.
Highlighting specific elements of the whiteboard display	Text, diagrams and pictures can be highlighted on the whiteboard, allowing teachers and pupils to focus on particular aspects of the display. It is often possible to cover part of the display and reveal it only when needed. This can be helpful when pupils are being expected to focus on just a part of a text or a picture. Some interactive whiteboard software includes shapes that can also be used to help pupils focus on a particular area. Sometimes, there is a spotlight facility which teachers and pupils can use to select and focus on a particular aspect of the lesson.

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Cut and paste	Sections can be cut and erased on screen, copied and pasted, undone and redone. These features help give pupils the confidence to take risks, as they know they can always go back or make changes.
Flip chart pages	These pages can be turned backwards and forwards, allowing teachers to go over particular aspects of a lesson or to recap areas that some or all of the pupils may not have understood. Pages can be viewed in any order and images and text can be dragged from one page to another. It may also be possible to make a link between pages, so that a teacher can move between a general statement and a more detailed analysis.
Split screen	Teachers can split the screen and display two different sets of things at once. This can be useful when exploring what happens if particular changes are made.
Rotate objects	This allows objects to be moved so that pupils can see symmetry, rotation and reflection.
Linking a digital microscope to the screen	This can provide a greatly enhanced experience when it comes to examining and discussing microscopic images.

These features can add significant value to teaching with an interactive whiteboard. For example:

- Using the drag and drop feature
- Using annotation and highlighting

Using the drag and drop feature

When using an interactive whiteboard, any item on the board can be moved to another position, using a technique called 'drag and drop'. This enables text or pictures to be moved anywhere on the board by pressing down on the item to be moved, holding it down and moving it, then releasing the pressure where you want it to stop – rather like moving a coin across the surface of a table. Using traditional methods, the same effect could be created by writing words on card or cutting out pictures and then sticking them to a board. However, doing this on a computer is much less time-consuming, easier to manage and reduces the need to store paper-based resources.

Being able to move items on screen helps with activities such as:

- Matching
- Labelling
- Grouping
- Sorting
- Gap filling
- Ordering

Pupils can experiment by trying the task and, if their answers are incorrect, simply moving items and trying again. Pupils say they find this more motivating than doing a task on paper

where errors are permanent. There can also be a discussion based around what is on the interactive whiteboard. Using careful questioning, teachers can encourage pupils to explain their actions, thereby demonstrating their understanding and sharing their knowledge with the rest of the class.

Tasks using drag and drop are ideal for starters as they can be used to gain focus in the classroom. They can also act as revision from a previous lesson or a lead-in to the current lesson.

Drag and drop activities can also be useful during the main part of the lesson or plenary sessions, consolidating knowledge and applying the new knowledge and skills to other topic areas or providing a focus for extension.

Using annotation and highlighting

With an interactive whiteboard, all the materials that can be accessed through a computer can be used in lessons, including charts, diagrams, animations, sound and video. The variety of materials enables a greater selection of teaching strategies and activities to be used and for a wider range of learning skills to be addressed.

When working at the interactive whiteboard, it is possible to take a pen and make notes, add comments, circle, underline or highlight anything that is on the board. How this is done depends on the type of board being used, but the key teaching advantage is that the interactive whiteboard can prompt greater discussion in the classroom, when supported by probing questions by the teacher. Of course, it is possible to underline and add notes on a traditional board. The advantages of using an interactive whiteboard are that:

- The notes are added to pages that have been prepared before the lesson.
- The notes can be kept once the lesson is finished, rather than erased.
- Different colours can be used as well as items such as a highlighter, which could only be achieved using an OHP slide with traditional methods.

The flexibility of the whiteboard for this type of activity provides greater engagement for pupils, especially kinaesthetic learners.

Notes and comments can be added over the top of anything that is displayed on the screen and then the notes can be saved within the file. This means that pupils can access the file later or pages can be printed for the pupils' notes. This technique can be adapted to a variety of tasks – any task that involves sorting, matching, grouping or ordering items can be done effectively on the interactive whiteboard.

Section 4: Pedagogy and the interactive whiteboard

The teaching and learning strategies you need to use when teaching with interactive whiteboards will not be unfamiliar. The features that make for successful lessons are the same, regardless of the technology or equipment you use. Successful lessons are well-designed and well-structured. They have clear learning objectives and outcomes and are broken into teaching episodes. This structure helps pupils to understand the content of the lesson and to relate it to what they already know.

The Key Stage 3 Strategy publication **Pedagogy and Practice: Teaching and Learning in Secondary Schools** sets out the characteristics of the teaching episodes in a typical lesson. These include:

- A starter activity.
- An introduction outlining the purpose and objectives of the lesson.
- The introduction of new learning or the introduction of a task. Typically, this will be the main area of whole-class teaching and may be repeated at different points of the lesson.
- The development of the learning by pupils.
- Plenaries at the end or during the lesson, providing opportunities to review what has been learned and reflect on the learning process.

The lesson structure is the same, whether or not an interactive whiteboard is used. Some aspects of lessons, however, can be enhanced by the boards. For example, the interactive whiteboard is particularly useful when using a style known as inductive teaching, in which pupils are expected to reach hypotheses based on sorting, classifying and re-sorting information.

The teacher can model different ways in which information might be classified using the features of the board, such as moving objects, and using colour and highlighting, while bringing pupils into the process. Pupils can

then work in small groups away from the board, taking the classification process further. They can be drawn back to the board at intervals so that different groups can present their thinking to the class for discussion, before continuing with the task.

The following section shows the phases in a typical lesson and looks at the contribution that an interactive whiteboard can make to each phase. However, this contribution ultimately depends on the materials used and how teachers exploit them, as well as how they interact with the pupils. The role of the teacher is still central in an effective lesson. The appropriate use of an interactive whiteboard can significantly support effective teaching.

The case studies give some examples of how interactive whiteboards could be used in mathematics to enhance learning and teaching during the different episodes of a lesson. Remember that these are only examples and that interactive whiteboards offer many more possibilities than suggested here.

4.1 Using an interactive whiteboard for a starter activity

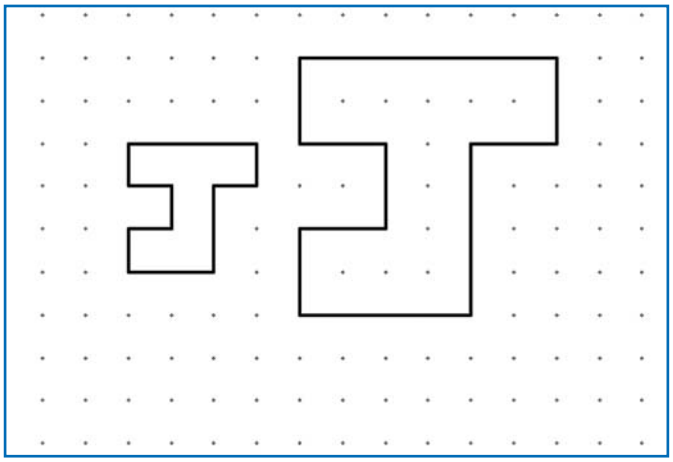
Teachers can use the dynamic nature of interactive whiteboards in a lively and engaging way in starter activities. Pupils can be set challenges using the board and can write their ideas on it. Teachers can also call up aspects of previous lessons to check pupils' recall.

Case study 1

This is a Year 8 lesson on enlargement. The resource used as the early focus of the work can easily be created by the teacher in advance in under ten minutes, using dynamic geometry software. Note that, having created the diagram, the teacher then uses the software to hide the centre of enlargement. The image is opened in time for the start of the lesson.

The teacher is working from the Key Stage 3 Strategy's Framework for teaching mathematics, Years 7, 8 and 9, focusing on the following Year 8 objectives:

- Understand and use the language and notation associated with enlargement.
- Enlarge 2-D shapes, given a centre of enlargement and a positive whole-number scale factor.
- Explore enlargement using ICT.



The teacher asks the pupils what they notice about the two shapes then, guided by the pupils, uses the line drawing function to join two corresponding vertices together.

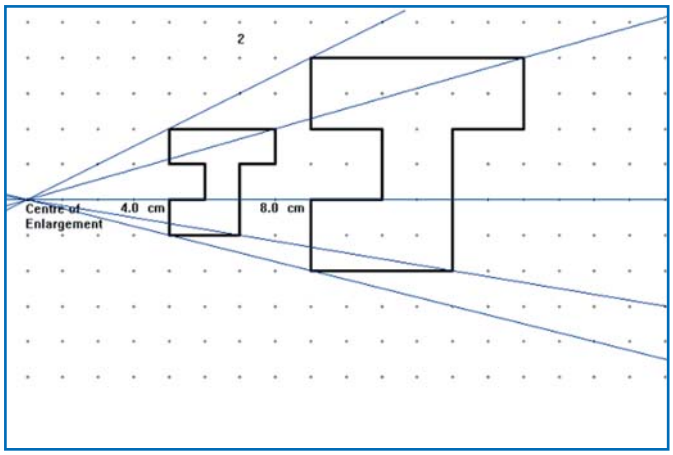
Pupils are then asked to predict where the intersection would be if another similar line were drawn, and a pupil volunteer comes to the whiteboard to draw this line in.

Discussion starts about what would happen to a third line through two more corresponding vertices, and again a volunteer constructs this line on the diagram. Pupils may express surprise that all three lines intersect at the single point. The procedure is repeated once more, to establish beyond reasonable doubt that the lines joining corresponding points would meet in this single point.

The teacher then reveals this point as the centre of enlargement and moves it to show the enlarged image moving to different positions. He then selects particular points and asks pupils to discuss where they thought the image would be if the centre of enlargement was located there.

Predictions are drawn on the board and then tested.

Comparing the two shapes reveals the scale factor and questions are asked about this.



Pupil volunteers increase or decrease the scale factor and the class observe the impact on the image.

This visual introduction is then followed up, with pupils drawing enlargements of shapes to a given scale factor linked to the centre of enlargement.

4.2 Using an interactive whiteboard for the:

- Introduction of new learning;
- Development of the learning by pupils.

Interactive whiteboards are useful for introducing new learning and developing learning in that they allow teachers to collect all the resources they need on their computer. This means that teachers can structure lessons carefully in advance, ensuring a smooth flow and maintaining a good pace.

Interactive whiteboards can make an important contribution to the presentation of new information, modelling new concepts and processes, creating simulations, stimulating discussion and explaining new ideas.

Once pupils have begun to learn new ideas, it is useful if they can practise their knowledge or apply the new concepts to a different context. This may be a time to discuss what they have learned or allow them to consolidate learning before moving on, and can be done away from the board.

Case study 2

This lesson is an adaptation of the main part of lesson N2.9, Equivalence of fractions and decimals, from the Key Stage 3 Strategy's publication, *Targeting Level 4 in Year 7: mathematics*. The pupils in this case study are a targeted group of Year 7 pupils, all of whom attained a secure level 3 in Key Stage 2.

The teacher is working from the Key Stage 3 Strategy's Framework for teaching mathematics, Years 7, 8 and 9, focusing on the following Year 7 intervention objectives:

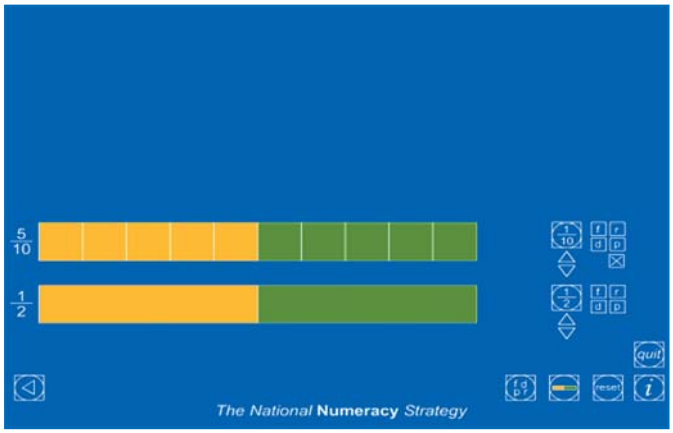
- Find fraction and decimal equivalents in simple cases.

- Use a calculator to convert simple fractions to decimals and interpret the display.

The teacher opens the Primary National Strategy Numeracy ITP *fractionspc* and clicks on the icon at the bottom of the screen so that two green number rods are visible. One is divided into halves and the other into tenths.

The teacher asks the pupils where half would be on the rod. Pupils indicate where $^1/_2$ would be on the lower line, the fraction shown at the end of the rod, and the distance matched by selecting in turn the boxed divisions on the upper rod. Pupils count $^1/_{10}, ^2/_{10}, ^3/_{10}, ^4/_{10}, ^5/_{10}$.

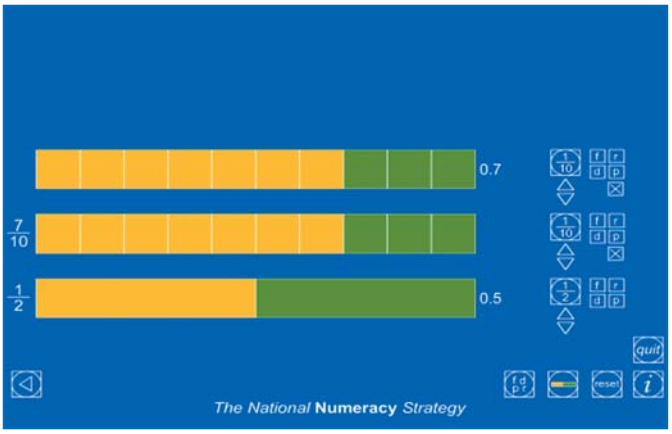
The equivalence is stressed $^5/_{10} = ^1/_2$ (see below).



The teacher then asks the class where one fifth would be on the rod.

Repeating the procedure as above helps to establish that for fifths, there would be five intervals, each equivalent to two tenths, and that $^2/_{10} = ^1/_5$. Equivalences for $^2/_5$, $^3/_5$ and $^4/_5$ are also established.

The teacher then introduces a third rod, separated into ten sections. This is to show decimal equivalents for each fraction. She points to $^7/_{10}$ and asks for its decimal equivalent (see above). This process is then repeated for other

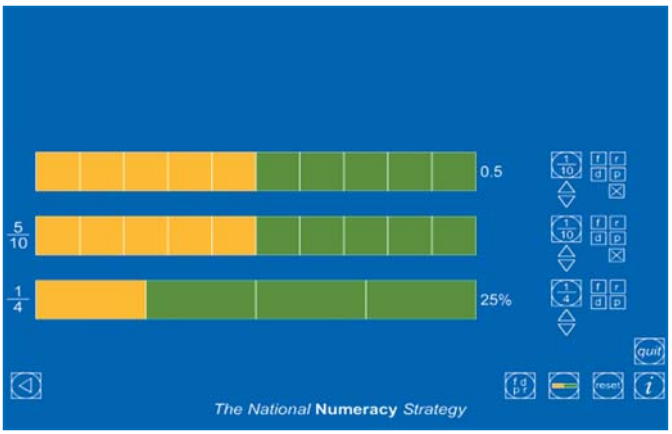


numbers, switching between the two lines. Halves are then compared on all three rods (still marked in the same way) to show that $^1/_2 = ^5/_{10} = 0.5$. This is written at the side of the board.

The teacher shows the pupils how to change the bottom rod to show fifths. By comparing $^1/_5$ on the bottom rod with the markings in the two rods above, pupils are able to write $^1/_5 = ^2/_{10} = 0.2$.

The class continues to establish that $^2/_5 = ^4/_{10} = 0.4$ and $^3/_5 = ^6/_{10} = 0.6$ and $^4/_5 = ^8/_{10} = 0.8$, again writing these at the side of the board.

Pupils are then asked how to show one quarter on the bottom rod. The teacher shows them that for quarters, there would be four intervals, each equivalent to two-and-a-half tenths.



In this case study, some of the pupils recognised $^1/_4$ as 25%, which also meant twenty-five

hundredths. By selecting the decimal equivalent, pupils then begin to recognize that $^1/_4 = 0.25$. Further exploration leads to $^3/_4 = 0.75$.

The principle is reinforced by pupils using calculators to convert $^1/_4$ and $^3/_4$ into decimals by calculating 1 ÷ 4 and 3 ÷ 4.

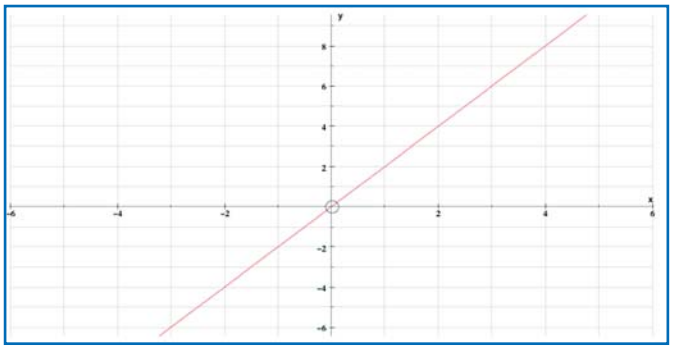
The main part of the lesson ends with pupils using their calculators to check the decimal equivalents for the fractions they had discussed earlier: $^1/_5, ^2/_5, ^3/_5, ^4/_5, ^{25}/_{100}, ^{75}/_{100}$.

Case study 3

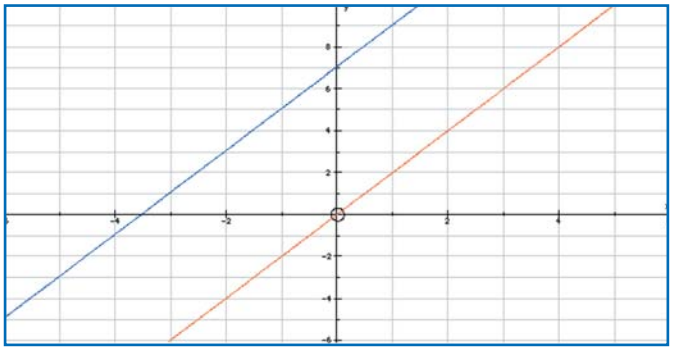
In this lesson, the teacher wants pupils in Year 8 to understand the link between linear equations and straight-line graphs. She is using the Key Stage 3 Strategy's Framework for teaching mathematics, Years 7, 8 and 9, focusing on the Year 8 objective: Plot the graphs of linear functions, where y is given explicitly in terms of x; recognise that equations of the form y = mx + c correspond to straight-line graphs.

An interactive whiteboard and graph-plotting software, such as Autograph, is used to allow pupils to test what would happen to a graph when the equation is changed in a way that would be more difficult with a pen and paper. The teacher uses graph-plotting software to show the resulting line graph which is produced from an equation. Pupils are then asked to predict what will happen to the graph when particular changes are made to the equation.

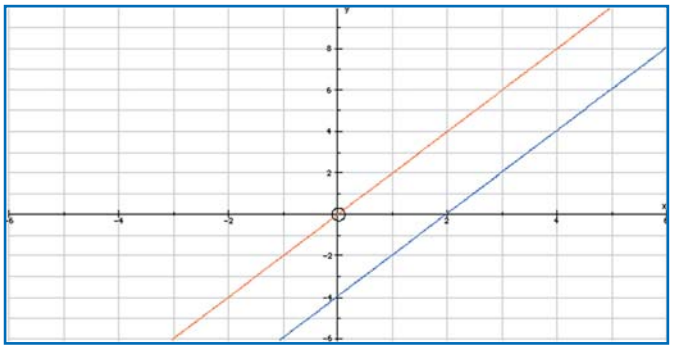
The teacher is able to plot coordinates of points fulfilling the equation y = 2x and to draw the straight-line graph onto the board. The continuous nature of the function is emphasised by the teacher asking pupils for a range of points on the graph, including those where x is large and positive, a decimal less than 3, a decimal negative, and so on.



The pupils are then asked what would happen if the equation were to be changed, say, to y = 2x + 7. Pupils draw lines on the board in 'virtual ink' to show where they think the line would move to. They explain their choices and check their choice of graph by substituting values into the equation:



Next, the teacher asks the pupils what would happen if the 7 were changed to -4. The teacher can take a snapshot of the screen to save the pupils' ideas so they can compare whether their ideas were correct and discuss why.

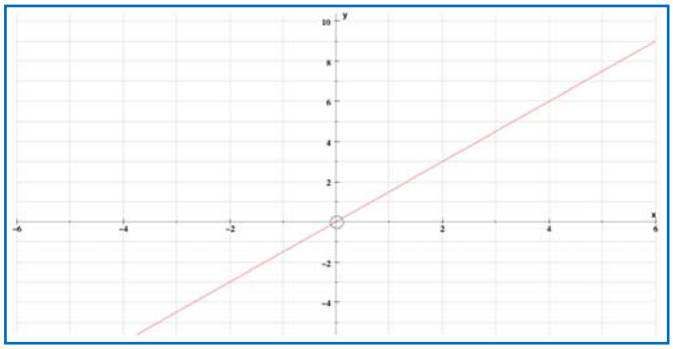


Pupils report that these methods help their understanding, because they are able to test ideas without making mistakes. Discussion in class also

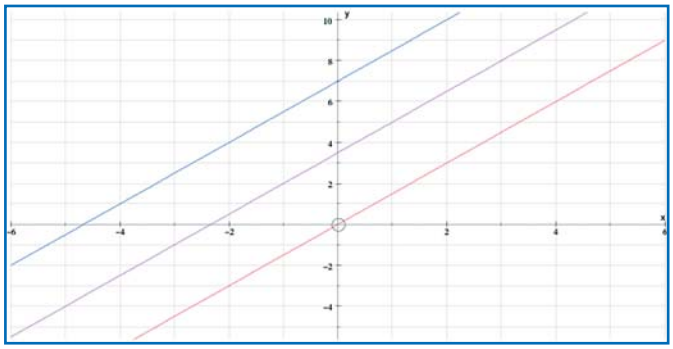
helps pupils to understand why the lines move as the equation changes.

After considering a few examples, with different gradients and different constant terms, and focused questioning by the teacher, pupils are able to generalise that equations of the form $y = mx + c$ produce graphs that are parallel to $y = mx$ and pass through the point $(0, c)$.

The teacher then asks pupils to suggest the coordinates of some points that lie on the graph of the equation $2y = 3x$. The points $(0, 0)$ and $(2, 3)$ are selected by the pupils and the straight line drawn.



The teacher now asks where the line $2y = 3x + 7$ would appear on the graph. Some pupils think that it would pass through $(0, 7)$ again. Their response was recorded on the graph and then the graph of $2y = 3x + 7$ was drawn, just to check.



The software provides the opportunity for rapid feedback, creating a cognitive conflict in this case that needed to be resolved. The teacher asks the pupils why the graph of $2y = 3x + 7$ passes through $(0, 3.5)$ and not through $(0, 7)$. Pupils substitute values into the equation to verify that this is the case.

After some discussion, the pupils recognise the need to make y the subject of the equation, in order to make their 'rule' of selecting the constant term to position the intercept on the y-axis applicable to all cases. They come to recognise that the equation must now become $y = {}^{3x}/_{2} + {}^{7}/_{2}$. This enables them to tackle more 'difficult' equations at an earlier stage than would have been possible without the interaction provided by use of the whiteboard.

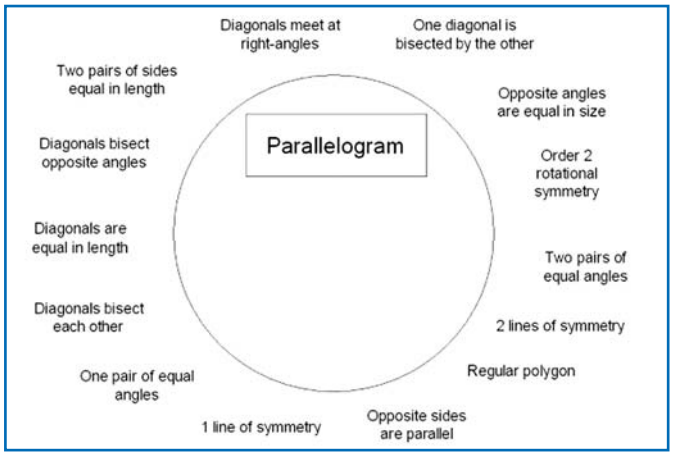
Case study 4

In this example, a teacher sets up a screen for a lead lesson in Year 10, for a unit of work on geometrical reasoning. This is a revision task where pupils are to demonstrate their knowledge of properties of quadrilaterals. Using whiteboard software, the teacher prepares a page with some properties of quadrilaterals and a circle as the focal point for gathering those properties associated with a particular quadrilateral. The preparation takes about 20 minutes. The task for the pupils is to link the properties to named quadrilaterals.

When planning this lesson, the teacher focuses on the objectives from the Framework for teaching mathematics, Years 7, 8 and 9.

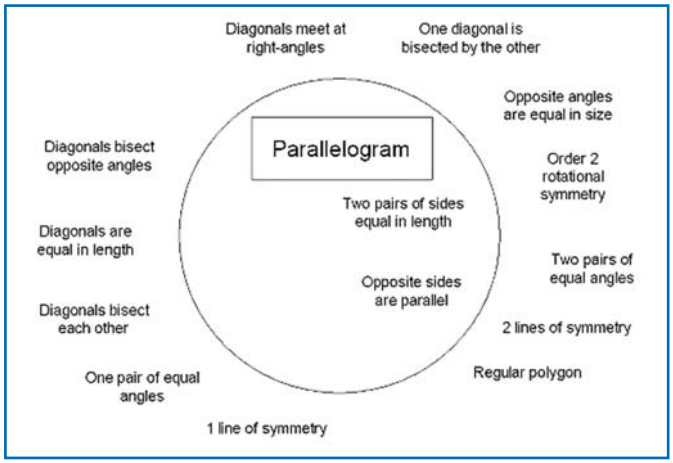
Year 8 objective: Solve geometrical problems using special quadrilaterals, explaining reasoning with diagrams and text; classify quadrilaterals by their geometric properties.

Year 9 extension: Distinguish between practical demonstration and proof; know underlying assumptions, recognising their importance and limitations and the effect of varying them.



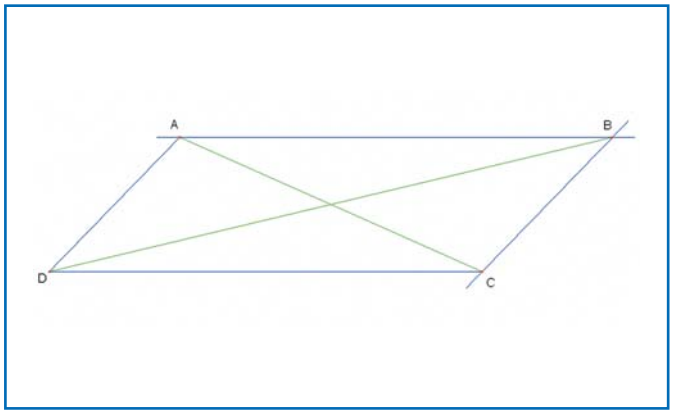
The teacher opens the file on the computer, providing an immediate focus in the lesson. Pupils start thinking about the links between the properties and the quadrilateral.

A volunteer pupil comes to the board and drags a property that would apply to any parallelogram into the circle.

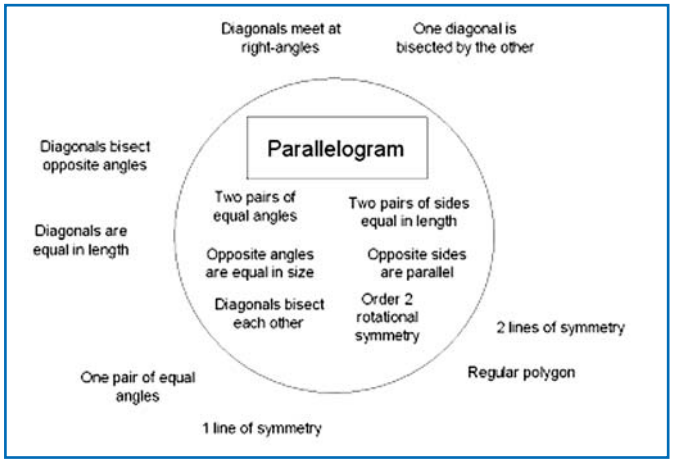


The teacher now asks the pupil to explain why she has chosen that property.

Pupils spend some time in small groups trying to find all the properties that apply to the named quadrilateral.

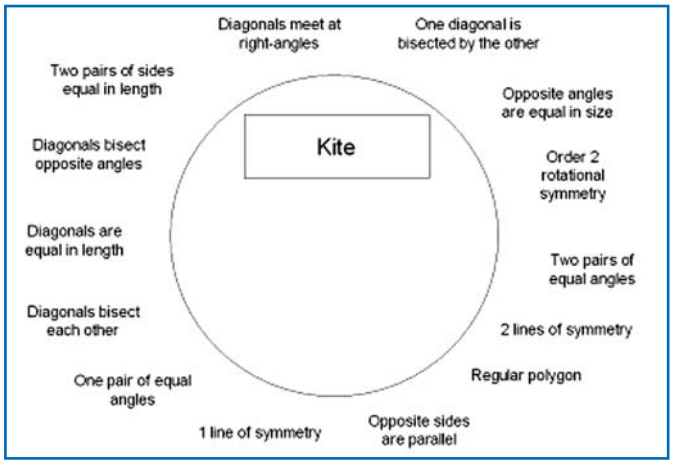


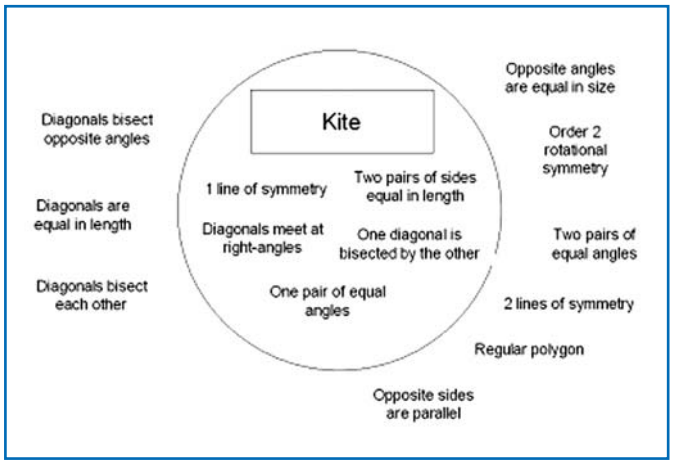
The teacher has prepared separate screens, using dynamic geometry software, showing each of the quadrilaterals being discussed. This enables pupils' conjectures and explanations to be worked through interactively with the whole class. It also provides a focus for discussions on proof and counter-examples.



The interactive whiteboard allows groups to suggest other properties that may apply to the parallelogram and test out their conjectures using the dynamic geometry software.

A similar model, supported by card sort activities, is then followed for other quadrilaterals.
The teacher's questioning prompts pupils to consider similarities and differences between the various quadrilaterals.





This task was quick and easy to set up. Using traditional methods, it could only be achieved with card and sticky tape or pieces of acetate on an overhead projector slide, both of which are considerably more time-consuming to prepare and require physical storage space if they are to be re-used. However, the dynamic imagery does require the use of computer or graphical calculator projection equipment. The files can be saved, re-used and shared with colleagues in school, or via the Internet with colleagues elsewhere.

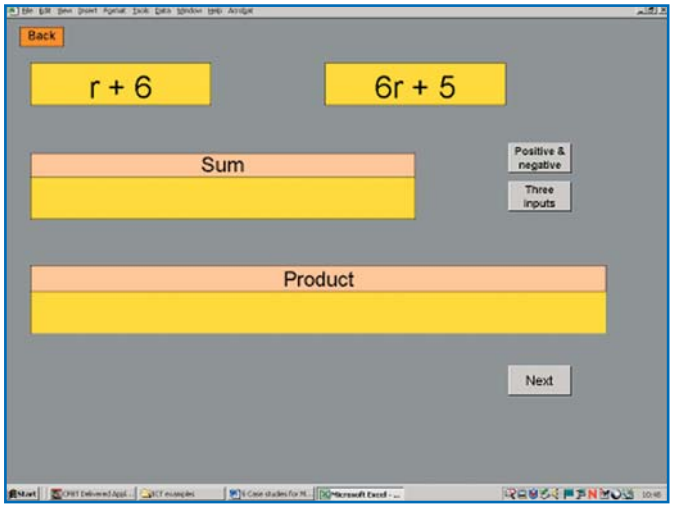
This type of activity could be adapted to work with any year group and could be extended to include cyclic quadrilaterals later in Year 10. It's also possible to start with the property in the circle and ask pupils to place in the circle all the quadrilaterals to which that property applies.

These activities are intended to support pupils' geometrical reasoning, which is assuming a greater significance in the curriculum. The array of properties of quadrilaterals that do not apply in each example will provide opportunities for exploring pupils' misconceptions about quadrilaterals. (How many pupils believe, for example, that a parallelogram has two lines of symmetry?) The teacher's questioning is crucial in this type of task, as reasoning and justification are the key elements.

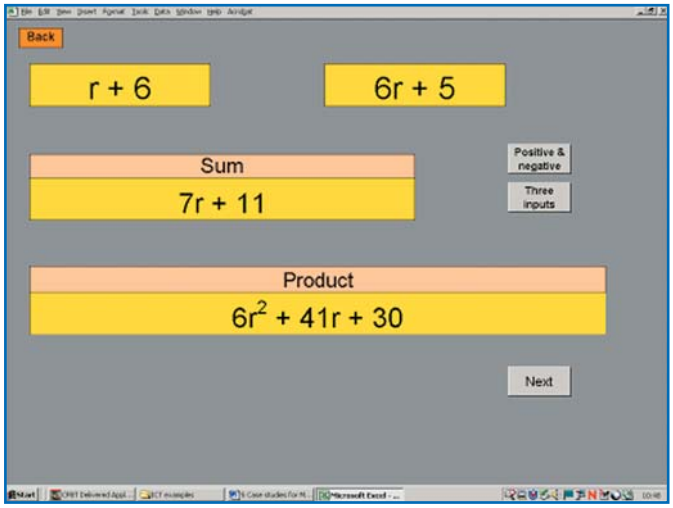
Case study 5

In this example, the teacher uses purpose-built mathematics software to improve pupils' facility with algebraic manipulation. Working with an able Year 11 group, this lesson reinforces earlier work on the expansion, and factorisation of quadratic expressions before leading into a more general factorisation of the equations of the form $ax^2 + bx + c$. The teacher uses a program from the ATM *Working with sums and products* interactive whiteboard software called **Sum and product with algebra**.

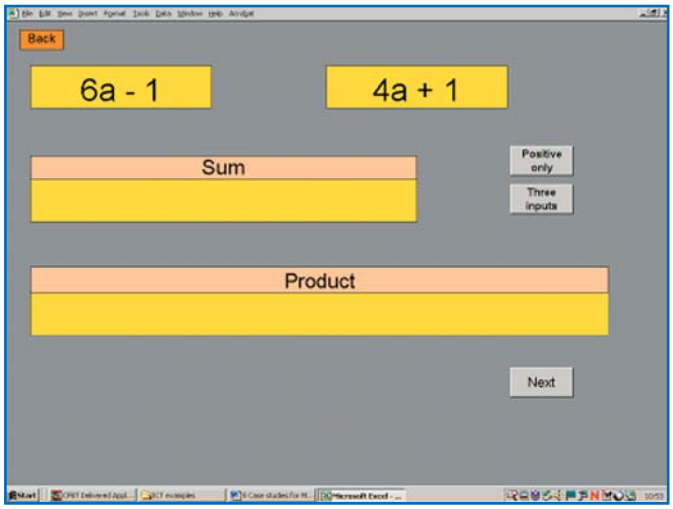
Pupils work away from the board in each example, working out the answer, and then use the software on the board to give their answers, explaining their reasoning.



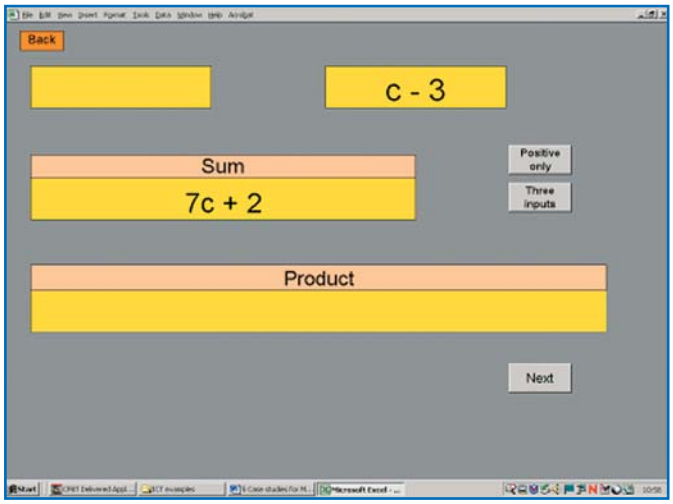
The first screen displays focus attention on the blanked-out areas. The teacher asks pupils to quickly work out the missing sum and product of these two algebraic expressions generated at random by the computer.



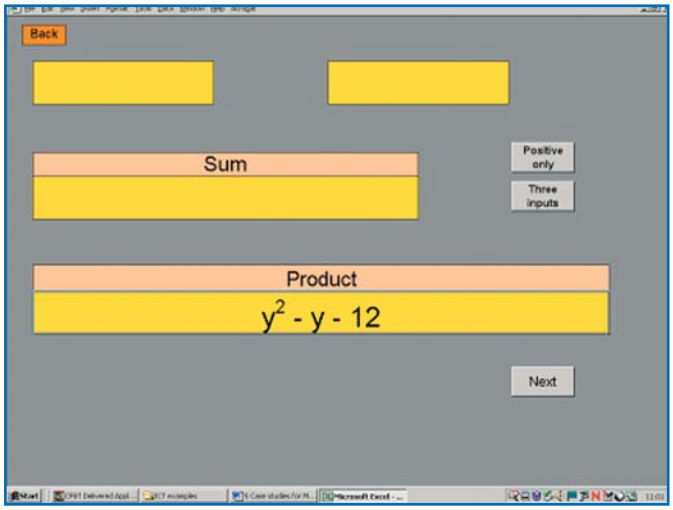
Pupils are familiar with this level of algebraic manipulation and quickly provide the solutions. Most use the grid method in their working.



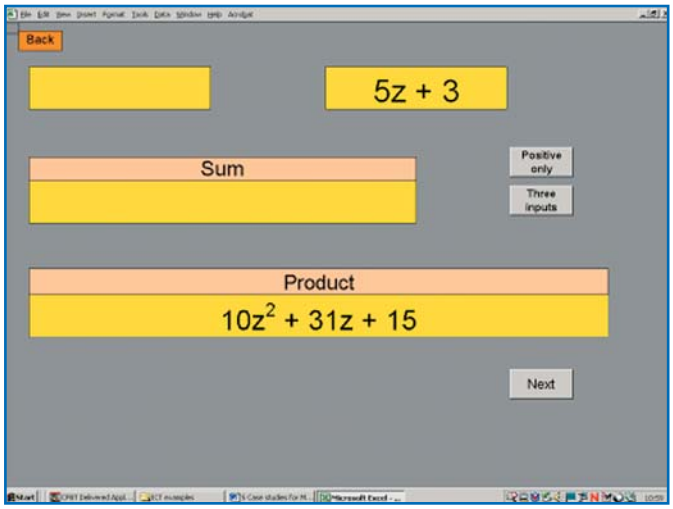
In other examples, the signs are varied.



Levels of complexity are gradually increased towards the end of the starter.

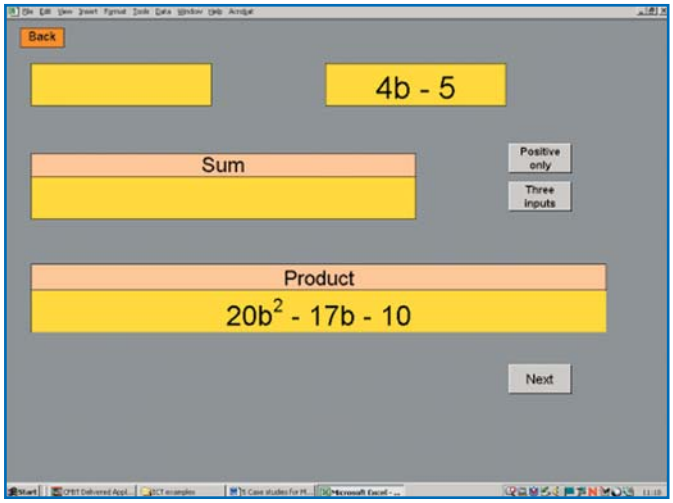


Pupils are already able to factorise expressions of the form $x^2 + bx + c$. As an introduction to the main part of the lesson, pupils are given a few examples to remind them of the methods used in this process.

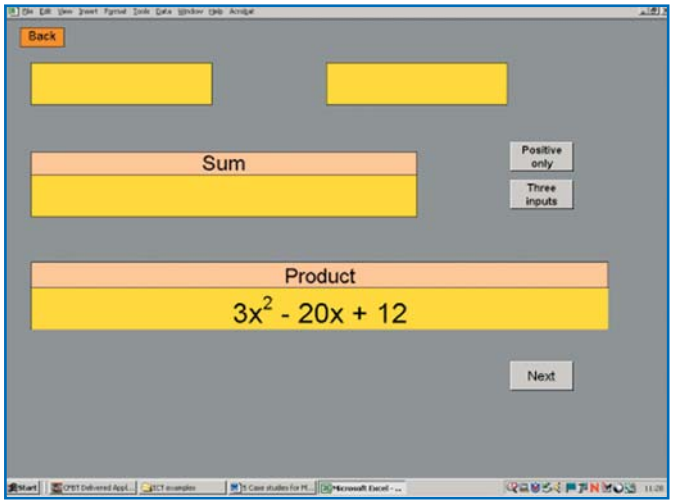


To tackle the main focus of the lesson, factorising equations of the form $ax^2 + bx + c$, where $a>1$, the teacher begins by setting a puzzle in which one of the factors is provided. Pupils model their solutions, and their reasoning, at the whiteboard.

In this example the factor of $2z + 5$ should emerge fairly quickly before pupils check by expanding the product.



Even at this early stage, pupils are beginning to verbalise their reasoning in finding solutions to these equations. By looking at the quadratic term and the constant, they determine that the missing factor must involve 5b and 2, and that the 2 must be positive. So the missing factor was $5b + 2$. They check their solutions by expanding the product.



Finally, they are given the product alone. The support provided through use of the software and the focus on discussion and reasoning provides them with scaffolding to arrive at a method which could be generalised. They then complete a few more practice examples before the plenary.

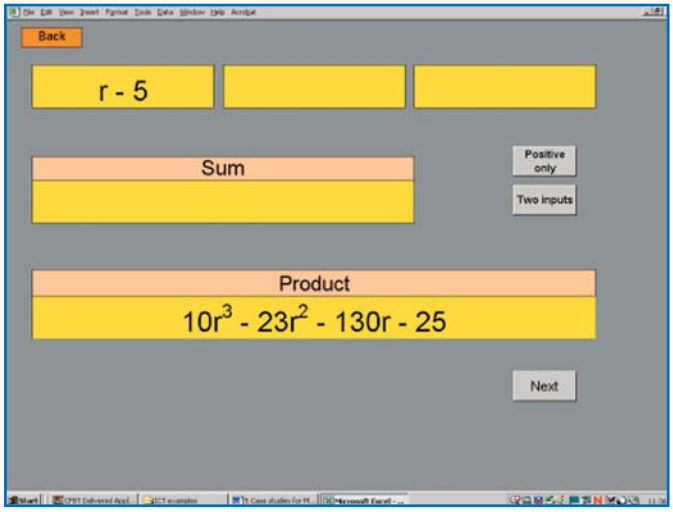
The levels of challenge and engagement generated here would be more difficult to achieve without the technology. The lesson would require greater preparation for a lesser outcome without the interactive whiteboard and software.

4.3 Using interactive whiteboards in the plenary session

Interactive whiteboards can contribute hugely to plenaries. Pupils can use the boards to present some of their ideas to the rest of the class for discussion, encouraging them to review and reflect on what they have learned. Learning can be reinforced with games and quick quizzes and the interactive whiteboard can also be used to point pupils to extension activities, such as websites related to the topic.

Case study 6

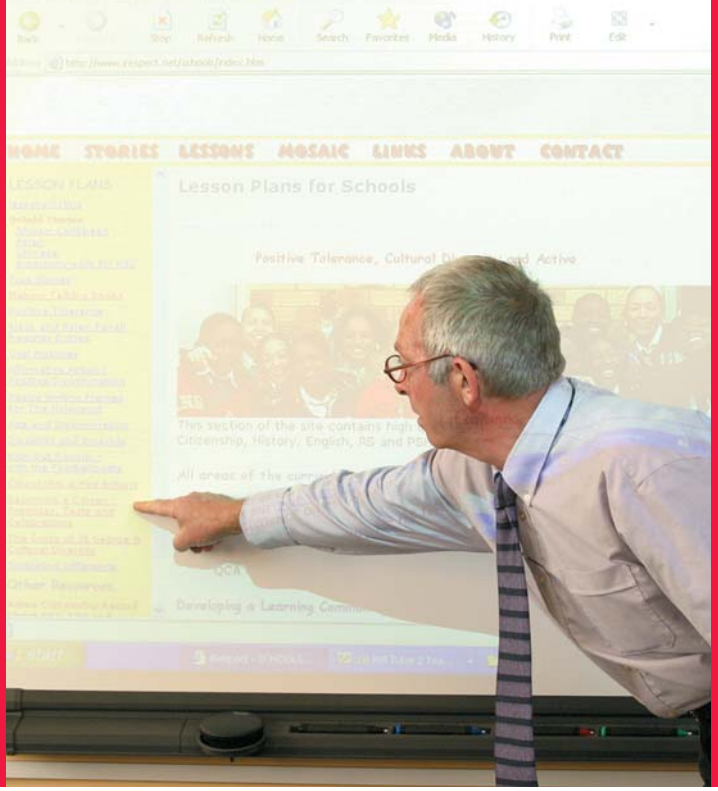
This plenary follows the lesson in case study 5. In it, pupils are able to share their methods by modelling solutions to the practice examples at the whiteboard, while others ask questions where appropriate. In the plenary, the teacher plans to provide a challenge to the pupils that will extend their learning in the lesson.



When the previous episode of the lesson has been completed, the teacher introduces this challenge, supporting pupils with well-structured questions. Eventually pupils realise that what they have to do is to work out the expression that, when multiplied by (r - 5), produces the required product.

Pupils begin by deciding that this has to be of the form ($10r^2 + ?r + 5$). After a few minutes, pupils produce the solution ($10r^2 + 27r + 5$), which then has to be factorised to solve the puzzle. Following on from the lesson's work, pupils should have little difficulty in establishing that the two remaining factors are (5r + 1) and (2r + 5).

Section 5: Emerging technologies



Interactive whiteboards have paved the way for a host of interactive technologies in the classroom. Some of these require an interactive whiteboard in order to work, some complement an interactive whiteboard, and others can work with just a computer and a projector.

Slate or graphics tablet

This wireless piece of equipment, which is about the same size as an A4 pad of paper, allows an interactive whiteboard to be controlled from anywhere in the room. This is done by the teacher or pupil holding the slate and using a special pen on it. The cursor on the board moves in line with the movements on the slate.

The tablet has advantages for classroom management, as the teacher can be situated anywhere in the classroom and still control all the functions of the board. In addition, the slate allows pupils who do not want to come to the board, or who are not physically able to do so, to participate fully in lessons.

Remote keyboards

Teachers or pupils can enter text onto the computer from anywhere in the classroom when using the remote keyboard. The keyboard works wirelessly with the computer, with any text typed being displayed on the interactive whiteboard. This is useful for shared writing activities or for a pupil to make notes directly onto the interactive whiteboard during class discussion.

Remote mouse

All the actions of a computer mouse can be carried out from any position in the classroom by this wireless device, also often known as a gyromouse.

Rather than moving over the surface of a desk, the remote mouse can be moved through the air to control what is happening on the screen. The remote mouse can be used from anywhere in the room.

Tablet PC

Using wireless connections to transmit data to a projector, the tablet PC can be used freely from anywhere in the room. Tests are currently being carried out to assess the value of using tablet PCs in this setting through the DfES Testbed project.

Voting devices

Voting devices allow teachers to ask pupils to vote electronically on questions. These could be multiple choice questions, with several options to choose from, or pupils could be asked to express an opinion across a range of answers (eg from A = agree strongly to E = disagree strongly). Some voting devices allow numerical answers to be entered. Teachers can even ask pupils if they understand or are if they are ready to move on. As pupils vote anonymously, they are less likely to be afraid to admit that they would like more time on a section of work.

Results from the vote are displayed immediately on the interactive whiteboard, allowing for immediate feedback on questions. Some software allows for detailed analysis of the results in order to offer more support to pupils who are scoring below the expected levels.

Digitizer

A digitizer is rather like an overhead projector that can enlarge opaque objects. It allows any small object to be enlarged and displayed on an interactive whiteboard. A teacher could, for example, open a book and place it on the digitizer. The page of the book would be displayed clearly on the board. Using the right software, images can then be annotated or saved.

Video conferencing technology

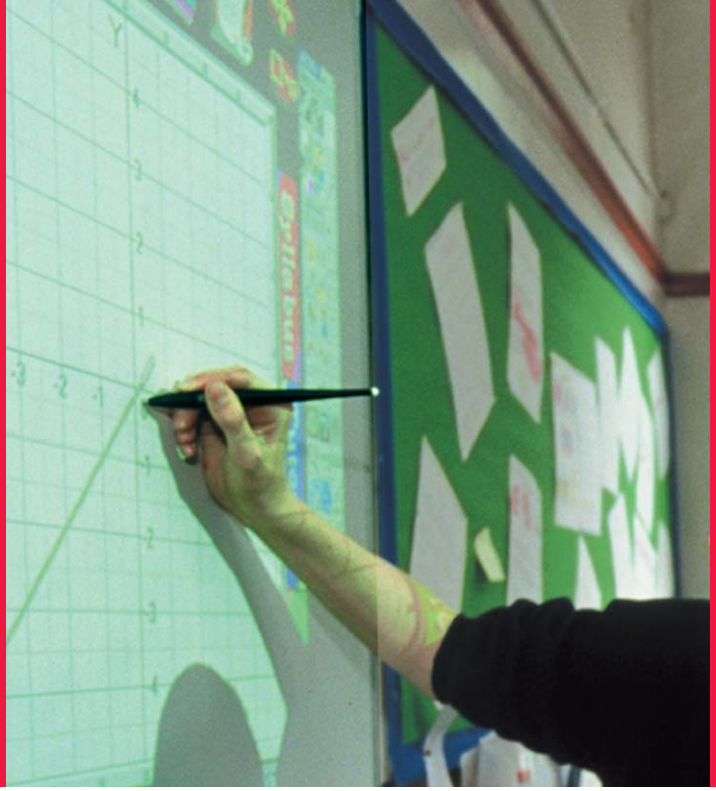
A computer with a webcam offers the possibility of video conferencing during lessons. Links can be established with people outside the

classroom and live streaming video displayed on the interactive whiteboard. Video conferencing technology enables 'experts' to contribute to lessons – for example, by linking up the classroom with a specialist who is able to answer pupils' questions from a laboratory, a museum or overseas. The video link can be recorded and replayed later in the lesson using the interactive whiteboard, to analyse or recall what was said during the interview.

Digital repositories

As the use of digital technology develops, so too will banks of resources that can be searched and downloaded to provide short video or audio clips for lessons. Searching the Internet for material can be time-consuming and ultimately frustrating, so the advent of resources which can be quickly and easily accessed and customised for particular lessons is a welcome development.

Section 6: Further links and references



There is a wide range of further sources of information, advice, resources and other materials available to help you make the most of the interactive whiteboard in supporting learning and teaching.

The Department for Education and Skills wishes to make it clear that the Department, and its agents, accept no responsibility for the actual content of any of the non-Department materials suggested as information sources within this document, whether these are in the form of printed publications or on a website.

Department for Education and Skills

www.dfes.gov.uk
Homepage for the Department for Education and Skills (DfES).

www.dfes.gov.uk/ictinschools
For information on all policy areas relating to ICT in schools.

www.curriculumonline.gov.uk
Online catalogue of digital learning resources.

www.learnevaluations.co.uk/findeval_intro.aspx
Homepage of Evaluate, a Guardian newspaper-run, DfES-appointed evaluation service for products registered on Curriculum Online.

www.schoolzone.co.uk/evaluations/findeval.htm
Features independent evaluations of thousands of web-based learning materials, as well as details of educational suppliers and products. DfES - appointed evaluation service for products registered on Curriculum Online.

www.teachernet.gov.uk
Homepage of TeacherNet, the Government gateway for educational professionals.

www.teachernet.gov.uk/teachingandlearning/secondary/ks4/
TeacherNet information about Key Stage 4.

www.publications.teachernet.gov.uk
Online publications for schools service. View, download or order paper copies of the latest publications.

www.standards.dfes.gov.uk
Homepage of the DfES Standards Site, containing information on the latest educational initiatives.

www.standards.dfes.gov.uk/keystage3/
Information on ICT across the curriculum in Key Stage 3.

British Educational Communications and Technology Agency

Becta main site
www.becta.org.uk
Website of the Government's key partner in developing and delivering its information and communications technology (ICT) and e-learning strategy for schools and the learning and skills sector.

Interactive Whiteboard Catalogue
www.whiteboards.becta.org.uk
Online resource enabling you to look at interactive whiteboard solutions, services, suppliers and pricing before having a site survey carried out. Using the site, you can compile a shopping list of items and find all the necessary information to place an order with a supplier.

ICT advice for Teachers
www.ictadvice.org.uk
Advice from Becta on the use of ICT in different areas of the curriculum.

Teacher Resource Exchange
www.tre.ngfl.gov.uk
Database of resources and activities designed to help teachers develop and share ideas for good practice. All resources on the TRE are checked by subject specialists to ensure they are of the highest possible quality.

National College for School Leadership
www.ncsl.org.uk
For information and advice on the strategic leadership and ICT course.

Qualifications and Curriculum Authority (QCA)
www.ncaction.org.uk/subjects/ict/inother.htm
For information on ICT in subject teaching.

Subject association websites
mathematics

The Mathematical Association (MA)
www.m-a.org.uk

The Association of Teachers of Mathematics (ATM)
www.atm.org.uk

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