

De laatste jaren hebben digitale schoolborden op grote schaal hun entree gemaakt in de Nederlandse wiskundelokalen. Maar wat doe je ermee als docent? Deze vraag leeft natuurlijk niet alleen in ons land, maar bijvoorbeeld ook in Engeland, waar het Interactive Whiteboard (IWB) al eerder gangbaar is geworden. In dit artikel beschrijft **Dave Miller**, een gebruiker van het eerste uur en internationaal erkend expert op dit gebied, op welke manier je in je les van deze borden gebruik kunt maken.

Enhancing mathematics teaching at the interactive whiteboard: background and ideas

Background

In some ways secondary mathematics classrooms (for pupils aged 11-18) in England have changed considerably since the start of the new millennium. In other respects nothing has changed. The revolution that brought about the change was the interactive whiteboard (IWB), with early adopters commenting on its advantages, despite the considerable costs. Whether it is 'better' is still under debate, but the standard mathematics classroom now in virtually all secondary schools in England will contain a broadband internet computer linked to either a data projector or to both a data projector and an IWB.

Where classrooms only have a data projector linked to the computer, PowerPoint is widely used and lessons are usually clearly sequenced and the pedagogical approach is basically exposition, example and exercise. In these classrooms, where there has been little real pedagogic change, pupils are given techniques, procedures or algorithms, then provided with examples on how these can be applied and given related exercises to complete (often referred to as Exposition, Example, Exercise). There will be some variation around more interesting mathematics and teaching, but only as a minor part of the learning. In some classrooms that also contain an IWB the experience of pupils will be similar. These are the classrooms of the twentieth century – apart from the technology nothing has really changed.

In other classrooms the IWB is the focus of teaching and learning and the pedagogic approach is much more interactive. Typically this might follow a pedagogy of 'at the board, on the desk, in the head' (Miller, 2007) or one of those identified in the digital technologies report of the NCETM (2010).

The 'at the board, on the desk, in the head' approach integrates the work that happens on the IWB and on

pupils' desks in order to help pupils' understanding (in their head). Unlike the Exposition, Example, Exercise model pupils will be expected to undertake activities, be actively involved in their learning, discuss mathematics with each other and the teacher and be asked open-ended and higher level questions.

The activities for the pupils will include use of real and virtual manipulatives. Real manipulatives refers to mathematical equipment used at the desk, which in England would include geoboards (also called pinboards), fraction walls, Cuisenaire rods, mathematical graph paper, mirrors, tracing paper, number squares, multilink cubes, polygon sets and card sorts. Virtual manipulatives are computer applets that replicate the real manipulative or provide a specially designed mathematical environment (examples include Wisweb, NVLM and parts of the NRich site).

With this approach higher order questions are those about analysing rather than those about remembering, understanding and applying (Bloom, 1956, as adapted by Anderson & Krathwohl, 2001). These analytical questions are concerned with seeing patterns; organising parts; seeing hidden meanings and identifying components. The questions typically involve words like arrange, analyse, classify, compare, connect, divide, explain, order, select and separate.

Teaching and resources

In the early days of our IWB work at Keele University we offered advice about IWB use (about to be updated); recognised the importance of continuing professional development, both technological and pedagogical; considered the two different modes of working with the IWB (creating a resource for use in the classroom and then using it with pupils); realised that storing all electronic resources in the IWB file for the lesson would improve classroom management; determined the main tools that mathematics teachers would need

to use frequently in each of the two modes of use of the IWB; as well as established our interactive pedagogy of the IWB. More recently we have created a professional development model for teachers using IWBs.

The ideas and IWB techniques illustrated here are typical of the way in which you can work with an IWB.

Resources referred to in the rest of the article are available in one of two file formats: as a flipchart for use with ActivInspire (Promethean Ltd. software) or as a notebook for use with Smart notebook (Smart Technologies) – these have most of the IWB market share in schools in England. All are in English. I have also supplied an appendix where links to relevant resources can be found.

Fraction example

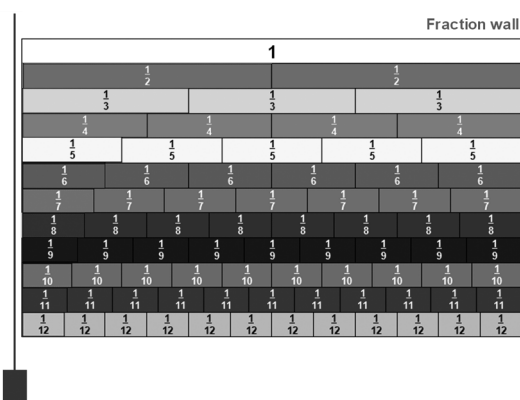


fig. 1 The fraction wall.

The fraction wall activity provides a ‘blank’ fraction wall and then a numbered version showing fractions. It has a vertical line that can be moved across the wall, allows multiple copies of the first fraction in each row to be ‘dragged’ out. Using the IWB software tools rectangles can be drawn to match any part of a row. On other pages an extra row is shown at the bottom, these can be reached quickly by a hyperlink to the page. The extra row shows, e.g. fifteenths; the idea is for the teacher to say to pupils “Which row is needed if you wanted to add thirds and fifths?” The teacher can then jump straight to this page.

At an appropriate point in the lesson pupils are given a copy of a longer fraction wall on their desk (which would contain fifteenths) to match what they see at the board. They would also have tracing paper so that they could trace out any fractions and move it around the fraction wall. Links to further resources and the pupil materials are included in the fraction wall file.

This example shows different representations of seven fractions, plus some other diagrams. Each separate dia-

gram represents a ‘card’ from a set of cards that will be given to the pupils. These cards will have been photocopied from a pdf file and may have been laminated so that they can be used many times. There are other IWB pages, with one for each separate collection of 8 cards. All of the individual ‘cards’ can be moved around the IWB page. Pupils, working in a pair would be asked to sort the cards into groups (e.g. where each representation is the same). With each individual part-set (e.g. the fractions) they could be asked to put them into numerical order. Discussion would come before and after the sorting of the cards. Pedagogically it is important that pupils can sort the materials in pairs on their desk and also that the teacher at the IWB can do the same. Having cards available on the IWB and having them moveable allows for improved questioning by the teacher and discussion by the pupils.

Ordering fractions and decimals

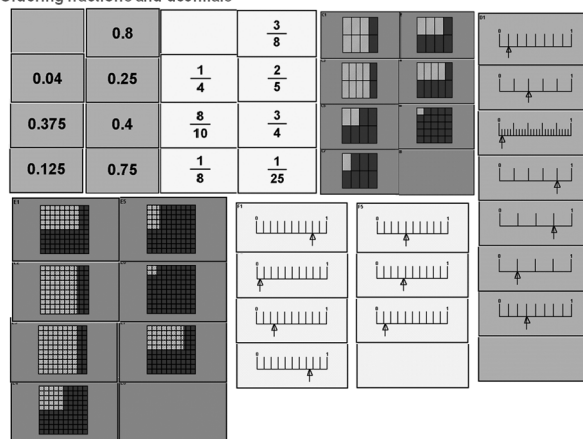


fig. 2 N1: Ordering fractions and decimals (from *Improving Learning in Mathematics*).

The approach and use of these ‘cards’ is common in many English mathematics classrooms (they are also called ‘sort card’ and the activity is referred to as a ‘card sort’.) This activity on decimals and fractions is one of the 50 activities which together form part of *Improving Learning in Mathematics*. There are full teacher notes for each. We have created an IWB file for each of the activities to save time for others and have stored the teacher notes in these files. It is relatively easy to make the cards from the teacher notes by use of the IWB software ‘on-screen’ camera and a fill option to colour them. Once you get used to doing it the page above could be made from the lesson plan containing the cards in about ten minutes.

Algebra Arrows

In England it has become increasingly difficult in many schools to find time at school for pupils to work on computers in mathematics (NCETM, 2010). However the IWB gives teachers an opportunity to work with the excellent Algebra Arrows from WisWeb.

At the start pupils can be shown the screen and be told that it shows two operations operating on a set of numbers that result in the graph as shown. They are asked to find the operations and the function of the graph. The red rectangles are there to hide the numbers. Once the pupils have found the operations pupils are provided with similar diagrams (for some only the graph would be needed). It works best if pupils, in pairs, are given a mixture of graphs (so only a few copies of each graph are needed). The IWB file will contain copies of all the graphs.

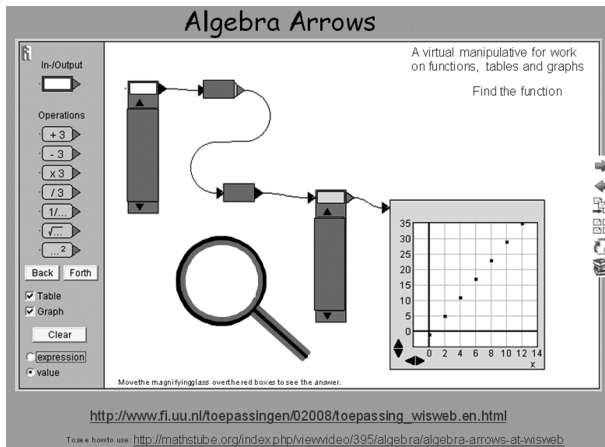


fig. 3 Algebra Arrows from Wisweb.

The aim of the lesson here might be about the gradient of the line and its relationship to the operations shown. If this were the case then questions that could be posed about different pictures given to the pupils are “What is the same?” and “What is different?” Conjectures could be tested by clicking through the link on the page to the WisWeb site and then using the manipulative.

The on-screen camera has been used to create the page from the website and red rectangles have been added to cover up values. The magnifying glass is what we call a ‘magic window’ since with it you can apparently see through the red rectangle to show the values underneath. There are many ways to do this and one way would be to create in red text the values that are in the table and then arrange the order of items so that the magic window (with a white centre, not a blank centre) passes over the red rectangle but under the red text, which will then show up on the white background. This is a common way to hide things (text and background the same colour until an action takes place).

Circle drawing

This activity is inspired by a competition organised by Mathematics and Education in Industry (MEI) based on the artist Giotto’s reported skill in drawing a perfect freehand circle. MEI organised a competition for pupils

to show how they would judge such a competition. We have since found that there was at least one such world championship and that there is a world champion!

Freehand circle drawing



<http://mei.org.uk/files/SeniorTMC2008poster-final2.pdf>

fig. 4 Freehand circle drawing.

This idea can be used in at least two ways: one to inspire pupils to find out the circle theorems and secondly as a revision of the theorems. In both pupils are provided with the historical anecdote about the twelfth/thirteenth century painter, asked to practice drawing a freehand circle on rough paper and then to consider how to judge the circles that they and others have produced. If this is a lead into circle theorems then work would now have to move into finding the properties of circles and use of, for example, Geometer’s Sketchpad, Cabri or GeoGebra.

Once the circle theorems have been established a set of freehand circles can be provided in advance, for pupils to test out their rules, before the real judging of each other’s circles. In the IWB file the rules from the prize-winning poster have been separated and hidden on separate pages of the IWB, to help as prompts for appropriate rules. After this practice all the paper drawn circles can then be judged by the pupils (you will also need to sort out a scoring system).

Pupils enjoy a freehand circle drawing competition at the IWB. They can be given up to two chances to draw the circle. The best three or four can then be selected by eye, and then the class rules can be applied to those left in to decide who is the freehand circle drawing champion. One way to do this would be to have them printed out and judged. Results can be kept and compared year-on-year. There are links in the IWB file to YouTube videos and to the prize-winning poster.

Parabolas

The final activity allows work around the standard quadratic graph of $y = x^2$. The on-screen camera is used to get two screen shots from a chosen graph plotter such as Autograph or GeoGebra. One is of a

background set of axes and a grid on which is shown the graph of $y = x^2$ in blue. This forms the background diagram on the IWB. In the other the axes and grid are not shown and the graph is coloured red and is at the bottom of the screen (in the example shown the graph would be of $y = x^2 - 6$).

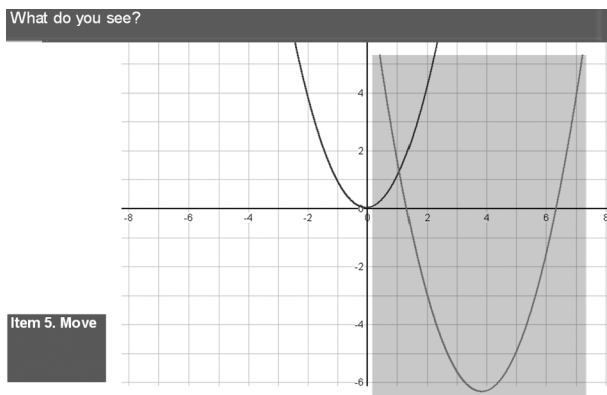


fig. 5 Quadratic graphs: what do you see and what can you do.

The IWB software is then used to adapt this second shot so that only the red line would be seen and then is grouped with a rectangle of ‘tracing paper’ – shown grey in the figure. This ‘tracing paper’ is made by creating a large black rectangle and using the software features to make it ‘partly transparent’. There are three advantages to using on-screen ‘tracing paper’ in this way: firstly, when grouped with the line it makes the line easier for pupils to move on the IWB; secondly it matches what is happening on the desk; and finally it is quick to do. To create this screen takes five minutes – once you are clear what to do.

Pupils are given a printed copy of the screen showing only the axes and the first graph. They are also given tracing paper and asked to trace onto it a copy of the graph. This basic set-up can then be used in a variety of ways, depending on the learning aims. Examples include understanding the link between the roots of the equation and the line of symmetry; and being able to find quickly the equations of given quadratic curves. The IWB allows the on screen ‘tracing paper’ to be moved around into many positions quickly without needing an equation and provides opportunities for conjecture and discussion with pupils.

Conclusion

The ideas here show a few ways in which the IWB can be used in the secondary mathematics classroom. The basic underlying themes can also be adapted for the primary (5-11 years old) classroom. The appendix below provides links to many more resources.

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- Bloom, B. S. (Ed.) (1956). *Taxonomy of Educational Objectives, The Classification of Educational Goals – Handbook I: Cognitive Domain*. New York: McKay.
- Miller, D. J. (2007). *At the board, on the desk, in the head: Using the interactive whiteboard to enhance mathematics teaching*. Retrieved 3 February 2012 from <https://www.ncetm.org.uk/mathemapedia/BoardDeskHead>
- Miller, D. J., Glover, D., & Averis, A. (2008). *Enabling enhanced mathematics teaching with interactive whiteboards: final report for the National Centre for Excellence in the Teaching of Mathematics* <http://bit.ly/iwbreport>
- NCETM (2010). *Mathematics and Digital Technologies: New Beginnings (2010)*, National Centre for Excellence in the Teaching of Mathematics <http://bit.ly/ncetmdreport2>

Appendix: resources

Interactive whiteboards: manufacturer training

Smart Technologies <http://smarttech.com/>

Promethean Ltd. <http://www.prometheanworld.com/en-gb>

At the board, on the desk in the head

<https://www.ncetm.org.uk/mathemapedia/BoardDeskHead>

Advice for teachers of mathematics

<http://bit.ly/iwbmilleradvice>

Files in English for use on the interactive whiteboard

ActivInspire files: <http://bit.ly/iwbmathsactiv>

Notebook files: <http://bit.ly/iwbmathssmart>

Training files in video format (in English)

www.mathstube.org.uk

Improving learning in mathematics (a set of publications)

Files, materials <http://www.nationalstemcentre.org.uk/elibrary/collection/291/materials>

IWB versions <http://bit.ly/iwbmathstrilim>