THE INTERACTIVE WHITEBOARD: IMPLICATIONS FOR SOFTWARE DESIGN AND USE.

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Changes to technology offer different ways of interacting with software, particularly for whole class teaching in mathematics. This paper looks at some of the issues for designing (and using) software or software files with one computer on its own, with a data projector and with an interactive whiteboard.

UTILITARIAN OR PEDAGOGICAL?

Software designed or used for educational purposes can be designated in two ways, according to its usefulness (utilitarian) or ways it may transform teaching (pedagogical). In business, the decisions are usually utilitarian. In teaching the pedagogical are considered obvious. I wish to argue that both the utilitarian and pedagogical aspects of software need to be more explicit for mathematics teaching.

An example of utilitarian software design is a spreadsheet. Its design followed the methods of financial record-keeping, totals, repeated operations on complete columns of figures etc. Even the name comes straight from its pre-computer use.

Pedagogy needs to be considered in both the design of software and in its use. Of course, there is not just one style of teaching with software. One useful way of considering the pedagogical aspects of ICT is described by Hewitt (2001) as that which works on assisting memory and that which educates awareness.

In "Mindstorms", Papert offered us an obvious impetus for pedagogical software design for awareness. Despite such a strong impetus to develop an awareness of geometry, LOGO is more often used for work on memory, memorising 'how to do Logo'. Geometry packages can be considered to be utilitarian, they draw accurately. Yet, the pedagogy of the developers is implicit, the facility to drag shapes offers many special cases to allow students to work on generalisation.

Senior management may concentrate on the utilitarian values of using ICT. Oldknow and Taylor (2000) suggest for the school ICT may "improve efficiency and reduce teaching costs" (p. 225). For teachers, utilitarian uses might be improving efficiency and reducing the burden of administration. For pedagogy, ICT may "be a stimulus to re-thinking their approach to mathematics teaching" or "be a stimulus to re-thinking their understanding of mathematics" (p. 225). The utilitarian aspects may initially be the more important way to encourage teachers to use software in their teaching, but it is the pedagogical that may be more important for design to enhance teaching.

A PROCESS OF EVALUATION

This work belongs within the practitioner research paradigm, as the researcher

> is someone who holds down a job … and is, at the same time, carrying out systematic enquiry which is of relevance to the job. (Robson, 2002, 534)

It is intended to be systematic enquiry into 'ordinary' knowledge and the implicit behaviours of a practitioner and to subject this to analysis to offer a stronger sense of that practice. It is also formative evaluation research, given that the process is

> intended to help in the **development** of the programme, innovation or whatever is the focus (Robson, 2002, p. 208, original emphasis).

This enquiry is intended to help with the innovation of integration of the IWB into the classroom through the design and use of software, yet, perhaps the most that can be claimed is illuminative evaluation (Partlett & Hamilton, 1976).

The major method lies in reflection upon personal practice as designer and tutor. Its focus lies in the consideration of the software/files that have been developed/used to identify features that relate to the categories described as utilitarian or pedagogical.

The data source is reflection on decisions made when designing spreadsheet files (ME@UB, 2000) and analysis of current work with teacher groups exploring their use of the IWB in mathematics classrooms. We have had a large television monitor permanently attached to the computer in our teaching room since 1997. This was used for exploring mathematics activities with our secondary pre-service teachers, sometimes for as short a time as five minutes. In order to vary the activities we design our own spreadsheet files (e.g. Perks & Prestage 1999, Perks et al., 2002.)

The initial IWB course, sponsored by Birmingham LEA, began in September 2000, the second in 2001. The authority provided each teacher with a laptop, fixed data projector and IWB and paid fees for a taught research degree. The teachers' research focus is on the ways the IWB may change the pedagogy within mathematics classrooms. To support this the teachers were given spreadsheet files, a geometry package and geometry files (Hewitt, 2000). Although many files had been written for individual use, the large screen display meant that these were also now suitable for whole class teaching. In each session, one of the teachers, my fellow tutor or I demonstrate some mathematics with one of these or their own files and then we work together on analysing the software in terms of opportunities for mathematics. Many of the files have been used in classrooms and sometimes a video of the activity has been shown to the group for consideration. It is these discussions and the changes to my practice in spreadsheet file design which inform the analysis described here.

ONE COMPUTER IN THE MATHEMATICS CLASSROOM

Where we once had one computer per school we now have computer suites. From the early days of teachers writing short programs we have moved to the larger software packages. There is still a place for teacher-written programs such as that in one of my local schools. This generates a random multiplication test with questions at timed intervals (followed by answers) which uses large fonts. The monitor is placed on top of a filing cabinet, visible to the whole class. Students have become used to the expectation of regular practice. Because of the computer, the situation is managed more easily. The task is directed by the computer, the teacher is free to monitor the room. The utilitarian features allow a different pedagogical opportunity.

Large Enough to See.

If you want to use one computer as a basis for work with the whole class, any work needs to be seen. The discovery that Excel allowed font sizes so large that a single number could fill the monitor and be generated randomly allowed me to design my own files. My first whole class use was with a file that generated random numbers to be used as bearings. The class task was based on students pointing in the direction of the bearing. The numbers were in multiples of 10, from 0 to 350. On a PC, pressing F9 recalculates the Excel workbook and produces a new number according to the formula. Analysis can be according to utilitarian and pedagogical characteristics.

Utilitarian	Pedagogical
Large font	Whole class involvement possible.
Numbers can be generated as many times as possible.	Opportunities for practice can be extended.
Machine chooses the numbers according to a formula.	The teaching decision – e.g. the use of multiples of 10 – is made explicit by the choice of formula.
The computer chooses the numbers and the order of presentation	There is an apparent shift in the perception of the task by students. The computer is seen as independent whereas many assume that the teacher is manipulating the choice in an undeclared manner.
The computer stores the file, ready for next time (not as easily lost as flash cards).	More, similar practice becomes possible because the tools are available.
The formula can be quickly adapted	The task can be changed to suit other mathematical content.

My initial changes to the formula were for use when practising angle, limiting the highest number to 90, 180 or 360 depending on whether the students were working on acute angles or extending to obtuse and reflex angles. Although these were pedagogical decisions, the task remains within the aspect of assisting memory. There seems no obvious way to extend use to the education of awareness.

As a teacher I like to use my materials for as many situations as possible. So I began to think of activities for which I used numerical flash cards, such as chanting tables, e.g see a number ending in 6 and subtract 7 from it. This lead to an extension of the file that allowed a new set of numbers simply by typing them into cells.

The pedagogical implications of choosing the set of numbers was highlighted when a primary teacher using the file commented that she used numbers from 0.25 with a gap of 0.25 for doubling then doubling. As her children worked on chanting responses, they realised that they always got whole numbers. Her pedagogical intention was to connect the 'fourness' of 'double, double' with the quarters hidden in the decimal numbers, the practice (assisting memory) was now enabling some children to work on the relationships between the different structures of number, (educating awareness).

The design of the file had been utilitarian; it suited me to be able to change the sets of numbers quickly. The implications of the design change were, however, pedagogical. The earlier example, subtracting seven from numbers of the form 10n+6, initially focussed on practice, but allows a chance to work on structure. This adaptability allows the file to become a more powerful tool for the classroom. What is important to stress is that many of the files do not, in themselves, permit the education of awareness, it is the pedagogical decisions, the teacher choices, which allow them to become useful and interesting tools for learning mathematics.

Another utilitarian aspect of fonts is the diversity of symbols. A formula is easily devised connecting numbers to letters. This allows a move to algebra. Chanting with numbers can become challenging if you are asked to multiply by 23 and subtract 27. If the letter 'a' suddenly appears there is the relief of chanting '23a minus 27'.

The key factors of design have been the size of display and the ability to change what the software is producing. A simple random number generator is enhanced by the addition of a general feature that allows the change of the generating formula in a way that does not depend upon programming skills. Much of what can happen with one computer is also true with the data projector. The great advantage is size.

THE DATA PROJECTOR

The advent of the data projector, especially when it is permanently fixed, in a mathematics classroom, allows whole class teaching to be supported by presentation software, such as PowerPoint, and files that were originally designed for individual use. Several of our teachers have produced presentations on curriculum content. This allows repetition of ideas; students can have pages played repeatedly. They can access the presentation if they have been ill. Revision may be seen to be revision, given the repetition. Students can be given notes. Many of these are why the software was designed and why the projector is so popular for sales presentations. Many of these features are also important for the use of the electronic whiteboard.

The data projector can also allow a change to pedagogical practice, for example graphs are easily available, and the teacher is more likely to use accurate diagrams more frequently, which supports learning in a different way. But this change, I would claim, is stronger if the projection is onto an IWB.

THE INTERACTIVE ELECTRONIC WHITEBOARD

The IWB is an important innovation in classrooms, initially, because it needs a data projector. But two aspects of the IWB are worth considering separately; the ability to write on the software and save this and any other images and the style of 'interactivity' the IWB allows. As little specific mathematics software has yet been designed for the IWB, much of the analysis is based on how the IWB software allows use, or how the IWB affects the pedagogy of working with existing software.

Writing and saving

The 'saving' aspect of the IWB offers similar advantages to those above, the extra facility is that anything is saved in the moment. Spontaneous teaching/learning situations can be captured. The IWB offers a powerful new feature; anything written or 'snapped' in the lesson can be revisited. Working on reflection, a student can be asked to draw an estimate of the image. This is saved. The image is then drawn by the software. You can then flip from the drawn to correct image several times – any impression of movement demonstrates differences between them.

Utilitarian	Pedagogical
Allows notes to be saved	The learner can ask to revisit any aspect of the lesson, examples are always available.
You can write on top of a software application.	Conjectures can be compared with or tested against the software.
You can write in different colours and/or on top of different copies of the same page of software.	Different approaches can be recorded and contrasted at other times.
	The relative merits of different conjectures can be discussed.
	Errors can be worked on collaboratively.

Interactivity

The whiteboard allows access to any of the menus or buttons via contact with the board. Handwriting recognition or the on-screen keyboard permit other aspects of programs to be controlled. Interaction with the software is not tied to the keyboard, but is related more to the traditional pointing at the board, familiar to teachers over the years. Standing close to the images, pointing at, directing changes, all of these add to a very different feel, a closer sense of working with the ICT.

A utilitarian design feature for any files includes the need for methods to remove reliance on the keyboard. In Excel, for example, random numbers are changed by recalculating the workbook, on a PC this is done by pressing F9, which is not on all IWB screen keyboards. The creation of a macro and its assignment to an on-screen button allow you to click on the IWB and recalculate.

Hiding and revealing become an important aspect of design, how often do we put our hands over the part of the board for emphasis? As the image is projected, the normal teaching tool of covering with your hand is no longer available, the files may need drawing objects to be used as masks, or macros written. Rectang (Hewitt, 2000) allows a rectangle to be dragged and its area and perimeter shown or hidden by clicking on buttons (assigned to macros). What might feel too fussy when working with these on an individual PC, is vital working on an IWB.

These features allow a teacher to work with the IWB in the ways they work with the chalkboard. The IWB restores the large movement teaching environment, not possible when restricted to a keyboard. What is new is the creation of interactive moments. Excel offers scroll bars to change numbers in a cell. We watched a video of a file being used in a classroom where the task was to guess a number given the clues 'too high' or 'too low'. Numbers could be typed in (using the on-screen keyboard), but the software designer (Earles, 2001) used a scroll bar. The sense of the mathematics, the number line related to the clues, was visible to us all. The motion of the 'drag' created powerful, public mathematics, which can be exploited.

Sometimes this power will lie in the task. Rectang (Hewitt, 2000) allows a rectangle to be dragged displaying its area and perimeter. It offers opportunities for conjectures and tests. With the IWB these can become public. One very public mathematical moment happened when a teacher was asked to keep the perimeter numerically greater than the area. We all shared his puzzlement from his body language. The moment when 'the maths was cracked' was visible and the sense of achievement noisily shared. This could have been done with the mouse, but this, I would argue, would not offer the same power that the public action has.

CONCLUSION

This paper has reviewed systematically aspects of software design/use to find a language and classification to inform design decisions. In working with the teachers, some specific design features have been important. Many teachers are designing their own files, or adapting existing ones. They write macros and create buttons, to hide and reveal and to move things about because these aspects have become a vital part of their practice with the IWB. In the initial stages these files often only fulfil a particular purpose. However, if the aim is to design material that will help to develop awareness, introducing variety becomes an important feature.

The IWB has the potential to transform mathematics teaching with ICT. If it is only used as an accompaniment to the data projector, it will not fulfil this. It is the creation of potential interactivity in the design that we need to emphasise.

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