Original article

Interactive whiteboards: boon or bandwagon? A critical review of the literature

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Abstract This article reviews the literature concerning the introduction of interactive whiteboards (IWBs) in educational settings. It identifies common themes to emerge from a burgeoning and diverse literature, which includes reports and summaries available on the Internet. Although the literature reviewed is overwhelmingly positive about the impact and the potential of IWBs, it is primarily based on the views of teachers and pupils. There is insufficient evidence to identify the actual impact of such technologies upon learning either in terms of classroom interaction or upon attainment and achievement. This article examines this issue in light of varying conceptions of interactivity and research into the effects of learning with verbal and visual information.

Keywords interactive, primary, secondary, teachers, technology

Background

This article reviews the literature about the introduction of interactive whiteboards (IWBs) as a pedagogical tool in educational settings, particularly use by teachers in schools. The review was undertaken as part of a research project funded by the Primary National Strategy to evaluate its 'Embedding ICT in the Literacy and Numeracy strategies' pilot project. This project investigated the impact of the use of IWBs for literacy and mathematics in Years 5 and 6 of the primary school (pupils aged 9–11 years) between 2003 and 2004. In particular, the evaluation looked to identify any impact on classroom interaction, on teachers' perceptions and on pupils' attainment, progress and attitudes. This review therefore concentrates on the evidence available in these areas.

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IWBs (or electronic whiteboards as they are perhaps more accurately called) are large, touch-sensitive boards, which control a computer connected to a digital projector. They were originally developed for office settings (Greiffenhagen 2002) and are a relatively new technology to education. Consequently, the available academic literature is limited and emerging only slowly. There are, however, a number of reports and summaries of small-scale research projects undertaken by individual teachers, schools and higher education institutions in the UK, USA, Canada and Australia. There are also descriptions of practice and teaching experience published in professional newspapers, journals and magazines. Most of these sources are available on the Internet.

In contrast to the slow emergence of evidence, the UK government is investing rapidly and substantially in the technology. The former Secretary of State for Education and Skills, Charles Clarke, is quoted as saying 'every school of the future will have an interactive whiteboard in every classroom, technology has already revolutionised learning' (Arnott 2004). While the impact of information and communications tech-

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nology (ICT) on learning is more debatable (e.g. Cuban 2001) and its impact on pupils' attainment relatively small (e.g. Higgins 2003) there is no doubt that this investment will have a substantial impact on teaching and learning environments in UK schools given the scale of the investment of over £50 million between 2003 and 2005 (Clarke 2004).

Before presenting the review it is worth sounding a couple of notes of caution. The first is regarding the quality of the data cited by many of the reports included in this review. Evidence is usually in the form of interviews, surveys and questionnaires relating to teachers' and pupils' perceptions of IWB use. Often these were informal and little information is included about the research methods used. Some caution is therefore needed in interpreting the findings. Also we were not able to identify any rigorous studies describing the impact of IWB use on learners' attainment or documenting actual changes in classroom interaction. This immediately raises a question about their overall impact on the processes and outcomes of learning. The second issue is that most reports do not distinguish between the broader benefits of presentation technologies and the specific or unique advantages of an IWB. This again makes it difficult to assess the impact of this specific technology. Given the paucity of such evidence, this article does not attempt to present an in-depth review of each IWB study; rather an overall impression of the findings and the critical questions such findings raise.

A tool for teaching and a tool for learning?

Two broad categories emerged in the reports reviewed: the IWB as a tool to enhance teaching, and as a tool to support learning. This article will focus primarily on these two categories, but will also review some of the common practical problems and issues identified.

Teaching

A number of themes were identified in the literature about the potential benefits of IWBs for teaching. These were:

- flexibility and versatility
- multimedia/multimodal presentation
- efficiency
- supporting planning and the development of resources
- modelling ICT skills
- interactivity and participation in lessons.

Flexibility and versatility

Teachers report finding IWBs a flexible and versatile teaching tool across age groups and settings (e.g. Austin 2003; Jamerson 2002), ranging from nursery (Wood 2001; Lee & Boyle 2003) to further and higher education (Malavet 1998; Damcott *et al*. 2000; Ekhaml 2002) and even distance education (Abrams & Haefner 1998; Bell 2002). This versatility extends to the content of lessons and activities. Smith (2001) reports on the benefits of using a graphics package to support younger pupils' handwriting skills where gross motor movements on the IWB helped their handwriting on paper. Similarly, younger pupils in Goodison's study (2002a) report a preference for using the IWB as opposed to a computer because they found the keyboard and mouse difficult to manipulate. Stallard describes the introduction of IWBs in 29 nurseries across Birmingham as having a profound effect on the number of pupils choosing ICT activities (Wood 2001). She found that pupils who would not normally choose to work on the computer were choosing to work on the IWB, and observed that they could do the activities without needing the fine-motor skills required to operate a mouse.

Teachers also report that IWBs extend possibilities when catering for a range of needs within a lesson. Miller and Glover (2002) describe one primary teacher's approach in splitting the IWB into three screens: each used to develop comprehension of a text at three levels with each group in turn. The facility to flip back and forth between pages on an IWB screen is also reported as a useful technique in supporting a range of needs within a class flexibly and spontaneously (Latham 2002; Levy 2002; Walker 2002b). As one teacher described (Austin 2003, p.2) 'I can see much more evidence of learning carried from one lesson to the next because of the ability for reinforcement on the fly'. Similarly, Walker (2002b, p. 2) reports on a primary teacher who finds the ability to 'flip back and review material' particularly beneficial for lower ability groups and pupils with special needs.

Multimedia/multimodal presentation

The range of materials and the facility to manipulate them is reported as a major benefit of IWBs across the curriculum. Levy's (2002) interviews with secondary teachers revealed that they drew on a greater number and wider variety of resources than is possible with other approaches. As one teacher commented, 'Now you can colour the lesson with sound, video and images depending on the topic'. Morrison (2003) describes using of a range of resources to bring secondary history lessons to life: 'I can take pupils into a First World War trench and give them a 360° panoramic view. I can then instantly enable pupils to hear a veteran evoke the sights sounds and smells of warfare'. Likewise, Evans reports on using PowerPoint presentations to present key facts alongside historical source images, written information and diagrams which can be highlighted to discuss the reliability of sources (Virtual Learning 2003a). Similarly, Johnson (2002) recommends the use of software to support multimedia literacy lessons. In mathematics, Edwards *et al*. (2002) found that real-time movement such as rotation alongside visual cues such as highlighting, supported the teaching of fractions, measurement of angles and a variety of transformations such as translation and tessellation. These authors also identify interactive games as a successful resource, commenting, 'not only did pupils thoroughly enjoy this program but they began to hone their responses to indicate more accurate decision-making and less guessing' (Edwards *et al*. 2002, p. 31). Carson (2003) also describes using interactive games such as number wheel spinning to support mathematics teaching. He suggests that this facilitated whole-class discussion, which led to the sharing of ideas and generation of theories. The trainee secondary teachers identified by Edwards *et al*. (2002, p. 31) found whole-class game playing on an IWB allowed them to monitor pupils' progress and 'to identify weaknesses or misconceptions very early in the activity so that these can be rectified'.

Modern foreign language (MFL) teachers are also reported as using a range of materials on an IWB. Thomas (2003) describes the use of CD-ROMs, websites, Word documents and PowerPoint slides in conjunction with the facility to highlight, annotate, drag, drop and conceal linguistic units: 'you can create sequences linking sound files, web pages, images – anything from your desktop and build it up, layer upon layer' (Thomas 2003, p. 2). The facility to mix visual and aural information is argued to facilitate the process of MFL learning, as learners can make connections between what they see and what they hear.

Efficiency

At this point it is worth considering that the most obvious distinction between IWB technology and other technologies incorporating a data projector and dedicated computer is the facility to control the computer at the touch of the screen (or technical interactivity as we shall call it). It would appear, however, that in terms of arguing for the IWB as a *tool for teaching*, this distinction is rarely made in the literature. It is therefore questionable how far the benefits reported (e.g. the use of multimedia resources and the facility to highlight information on screen) relate to the unique touch-sensitive nature of IWBs or merely form part of an uncritical bandwagon effect: the success of a new technology is perceived inevitable.

Some educators have argued, however, that the touch-sensitive nature of IWBs facilitates a more efficient presentation and more professional delivery of multimedia resources (Boyle 2002; Thomas 2002). Glover and Miller (2001, p. 264) report one teacher's summary of the benefits as 'instant access to material from a variety of sources and the possibility of using pre-prepared lessons that move without apparent effort from the visual to the verbal and back again'. Similarly a primary school teacher reflecting on her own practice notes that IWBs enable a smooth transition between activities within a lesson (Virtual Learning 2003a). The North Islington Mathematics Project also found a 'seamless flow' from one teaching point to the next in maths lessons with an IWB (Latham 2002). Similarly, teachers also report that IWBs quicken the pace of lessons. Several have noted that there is less time spent on 'a preoccupation with management of resources' (Latham 2002, p. 7), such as throwing of dice in maths lessons as opposed to the tapping of the board for a virtual throw (Ball 2003).

Supporting planning and the development of resources

Although it can take time to prepare lessons with an IWB and to become technically accomplished (Glover & Miller 2001; Greenwell 2002; Levy 2002; Ball

2003), teachers report that planning time should eventually be reduced given the facility of IWB technology to save, share and re-use lesson materials (e.g. Lee & Boyle 2003). For example, one of the teachers interviewed by Levy (2002, p. 14) believed that the extra time spent in preparing lessons would be 'an investment – putting in the time [at school] and at home – all those resources that I prepared this year are now still there – I believe my work will be a lot easier form now onwards'. Secondary school teachers interviewed by Glover and Miller (2001, p. 263) saw the ability to save materials on an IWB as 'a means of teaching development based on reflections not just from lesson to lesson but also year to year'. Certainly some secondary schools are sharing resources prepared on and for IWB lessons across the school via the school network or intranet (Boyle 2002; Levy 2002). A headteacher in Miller and Glover's (2002) research pointed out that this could save money in the long term as resources could be used more efficiently. It is not yet clear to what extent these possible benefits will actually materialise without evidence from longitudinal studies. Moreover, as in the previous section, it is unclear the extent to which such benefits relate to IWBs per se, as similar benefits have also been attributed to the increased computer access facilitated by the Laptops for Teachers initiative (DfES 2004).

Modelling ICT skills

Improvements in pupils' ICT skills are often acknowledged as an incidental benefit and seem to relate to the fact that teachers are modelling the skills as they use IWBs to teach across the whole curriculum. Hence pupils are able to 'observe the manipulation of the operating system, the main applications and the network structure on a routine basis, so that when they come to use computers in class . . . they are fully aware of what needs to be done' (Goodison 2002b, p. 288). Pupils' comments in Goodison's (2002b) study seem to support this view. One primary school in Australia reports that they no longer explicitly teach some ICT skills as pupils gain enough experience watching the IWB in use and using it themselves (Lee & Boyle 2003).

Improvements in ICT skills are also said to be due to the size and clarity of images on an IWB. Pupils are able to watch a teacher demonstrating a particular program (Bell 2002; Levy 2002) and this may be easier to follow than the movement of a mouse pointer across a small screen (Smith 2001; Christchurch 2003; Tameside MBC 2003). It is certainly easier for a class to see than crowding around an individual monitor (Buckinghamshire LEA 2002; Gage 2002). As Levy (2002, p. 7) summarises, 'it eliminates disruption associated with movement around the classroom, improves visibility for the students, and reduces time spent in repeating explanations to individuals or writing out procedural instructions on a traditional board.'

Facing the class whilst teaching ICT is reported as a major advantage of IWB use (Becta 2000; Bell 2001; Smith 2001; Drage 2002; Wood 2001; Christchurch 2003). As Wood (2001, p. 3) comments, working at a computer to the side of a board means that a teacher is physically detached from the visual presentation, and may even be 'more in tune with their laptop than with the children'. Hence, facing the class allows the teacher to spend more time focussing on the pupils (Smith 2001; Ball 2003). Physical proximity to the board is reported as being particularly advantageous for teaching deaf pupils, who would no longer have to glance away from the visual image on the board to the teacher's signing, as both images would be within their line of sight (Carter 2002). Teaching from the front of the class with the aid of a board is a familiar or comfortable pedagogic stance for most teachers. This is claimed to support more 'technophobic' teachers to engage with IWBs and integrate ICT into their lessons (Brown 2003; Becta 2003; Christchurch 2003).

Interactivity and participation

One of the major advantages claimed with regard to IWBs as a teaching tool is that they are 'interactive'. Becta (2003, p. 3) states that students are motivated in lessons with an IWB because of 'the high level of interaction – students enjoy interacting physically with the board, manipulating text and images'. For example, Austin (2003) reports the use of a number program where the pupils themselves came up to the board and, using the pen, count forwards or backwards on a number line. However, despite reports that pupils' 'eagerness to come up and write on the board has been quite overwhelming' (Virtual Learning 2003a, p. 2), evidence from research suggests that not all teachers are involving pupils to this extent (Bell 2001;

Levy 2002). In fact some would claim that pupils' active involvement with the board during whole-class teaching reduces the pace of the lesson and can cause boredom (Smith 2001). Another word of caution is offered by Thomas (2003), who notes that teenagers may not be as eager to leave their seats as younger pupils. Smith (2001) also reports that some pupils find the boards difficult to manipulate.

Becta also say that IWBs present 'more opportunities for interaction and discussion', thereby exemplifying the ambiguity contained within the term 'interactive'. As well as promoting the *technical* interactivity of IWBs, broader pedagogic claims are also being made that IWBs facilitate more interactive lessons. Some of the reports link this idea of *pedagogic interactivity* with pupil participation in whole-class interactions. For example, the IWB was felt by some teachers to enhance teacher–pupil interaction, 'by encouraging students to offer answers to questions, which if correct can be noted on a flipchart' and was supported by the 'the strong visual and conceptual appeal of the information and learning resources that are displayed' (Levy 2002, p. 8). The implicit structure of such lessons, however, is reminiscent of the pattern of interaction commonly encouraged in classroom without IWBs: namely, the recitation script (Tharpe & Gallimore 1988). The recitation script has been criticised for limiting the possibilities for quality interaction by placing the teacher in the role of didactic expert and critical evaluator with the power to direct, question and evaluate students, whilst simultaneously removing power from students to ask as well as answer questions, and to evaluate their own and others' understanding (e.g. Edwards & Westgate, 1994; Wood 1992). This pattern of questioning 'seeks predictable correct answers and only rarely are teachers' questions used to assist pupils to more complete or elaborated ideas' (Mroz *et al*. 2000, p. 2). In short, therefore, although some of the IWB literature expounds the virtues of IWBs in encouraging pupils' verbal and physical participation in lessons it does not necessarily question the *quality* of that participation. Esarte-Sarries and Paterson (2003) refer to such broad pupil participation as surface features of interactive teaching, whereas more reciprocal acts of communication in the search for joint meaning making are classified as deep features.

Some of the IWB literature does consider the quality and depth of classroom interaction and participation in associating interactivity with more social constructivist views of education and learning. For instance, it argued that the scale of the boards enable the visual information to be more easily shared, thereby 'drawing the class together' (Levy 2002, p. 11). As one pupil in Levy's study (2002, p. 11) put it, 'I like the whiteboards because they are big and everyone can join in what's going on'. As a result, pupils may be encouraged to alter their role in classroom interactions by asking questions which can be explored immediately on the IWB (Levy 2002). Supporting pupils in asking as well as answering questions during IWB teaching, is also reported by primary school teachers (Cogill 2002) and in secondary science (Blane (2003). One of the teachers interviewed by Cogill (2002, p. 3) noted, 'Sometimes I might not have the answer but another child might. So it does change questions and answers ... there's more interaction, there's more involvement from everyone in their learning'.

In such a social constructivist model of classroom interaction the teacher is viewed as mediator between the computer and software, and the pupils' learning experience (Wiggins & Ruthmann 2002; Warren 2003). This has several implications, including the positioning of the teacher within a classroom. For example, Cogill (2002) describes pupils using a mathematics website to manage their own learning whilst their teacher stood to one side. Bell (2002, p. 3) describes a scenario in which the teacher is stationed at the computer, 'with students at the board and in the class offering suggestions and physically contributing ideas and actions'. The use of interactive 'tablets' with an IWB in a primary school enabled one teacher 'to be with the children rather than standing at the front doing the chalk-and-talk thing' (Walker 2002a, p. 2). Greiffenhagen (2002) describes a school in Duisberg, Germany, which created a 'computer-integrated classroom' by installing an IWB, which worked with several electronic tablets used by both teachers and pupils. This equipment largely removed the need for the teacher to stand in front of the class to manage the lesson: an interesting point when a major benefit of IWBs in teaching ICT is identified as the teacher standing in front of the class (Becta 2003).

Another implication resulting from this model of learning is the acknowledgement that pupils also benefit from working together in small groups. Not all of the teachers interviewed by Levy (2002) agreed that IWBs encouraged whole-class interaction. Some suggested that because IWBs presented the introductory part of lessons so efficiently, more time was freed for 'interactive activity-based learning'. Where IWBs have been installed at the right height for pupils in nursery schools, teachers have noted greater collaboration and sharing of the task than typical of work at a computer (Wood 2001, p. 5). Smith (2001) however suggests that fixing an IWB to a wall militates against collaboration, as only one pupil at a time can be stationed at the board while the rest must sit remaining out of the way of the projector.

Pupils in Levy's study (2002) reported that sharing their work with others in the class helped them to articulate their ideas and give explanations. They also enjoyed the opportunity to see and discuss other pupils' work. Birch (2003), Glover and Miller (2001) and Walker (2003a) all report that pupils were good at listening to each other, and are supportive and encouraging when a class member is at the board. It is possible that pupils' anxieties in making mistakes in public are reduced given the temporary and alterable nature of work on an IWB, as argued by Carter (2002).

The use of an IWB to encourage an interactive environment wherein pupils actively participate in the social (re)construction of knowledge and understanding is presented as a means to transform educational practices (Burden 2002). However, it is clear from the literature that this is relatively rare (Glover & Miller 2001; Burden 2002). Levy's classroom observations suggest that even though some teachers felt that IWBs promoted teacher-pupil interaction, the most interaction occurred after whole-class teaching when pupils were working on individual tasks. In other words, the one observational study of IWB use found that far from transforming classroom practice, the new technology appears to have been uncritically absorbed into teachers' pre-IWB practice.

The IWB as a tool to support learning

The second theme in the IWB literature concerning the unique features of IWBs relates to the promotion of pupils' learning and falls into the following categories:

- Motivation and affect
- Multimedia and multi-sensory presentation.

Motivation and affect

The most widely claimed advantage of IWBs is that they motivate pupils because lessons are more enjoyable and interesting, resulting in improved attention and behaviour (see, e.g. Beeland 2002). Pupils report that their lessons are faster paced, more fun and exciting (Levy 2002). The attributed cause of such engagement is varied and includes quality presentation (Becta 2003) incorporating large visual images (Smith 2000) with a more modern or contemporary feel which satisfy the expectations of pupils already immersed in a world of media images (Glover & Miller 2001; Beeland 2002). Birch (2003) reports anecdotal evidence that boys are more involved in literacy lessons. Teachers too seem motivated by the boards and this influences pupils' perceptions (Cogill 2002). Teachers in Levy's (2002) study felt that pupils were full of anticipation and interest for what would appear next on the board. Similarly, teachers in Miller and Glover's study (2002) felt that pupils' zest for learning was enhanced by the element of surprise that IWBs and accompanying software can bring to lessons. Others suggest that programs used on IWBs offer positive feedback for correct answers (Richardson 2002), or sound clips to correct or signify repeated errors (Miller & Glover 2002). Teachers in the North Islington Mathematics Project reported that the investment of time and effort in preparing IWB lessons was reflected in the pupils' work (Latham 2002). The opportunity to use the board to present and discuss one's own work, or become involved with, e.g. a class vote, is also acknowledged as likely to improve attention and engagement in the learning process (Bell 2001; Burden 2002; Miller & Glover 2002; Becta 2003). This is the reason Kennewell (2001) argues that pupils must be allowed to use IWBs themselves. There are some concerns, however, that the 'novelty value' of IWBs may wear off as pupils become accustomed to their features (Levy 2002; Miller & Glover 2002; Becta 2003).

Much of the evidence for these observations is anecdotal; however, a study by Weimer (2001) measured student attitudes and motivations towards a class project using an experimental design. The results

showed improved motivation for pupils in the class using an IWB.

Multimedia and multi-sensory presentation

Another feature of IWBs, which is claimed to promote learning is their multimedia and multi-sensory capacity. The presentation of stimulating visual images is claimed to enhance pupils' recall: 'when I talk to the children about what helps them remember, they say they can still see the images in their mind, even after we have finished a lesson' (Burden 2002, p. 17). Similarly, science students reported that the IWB had helped them remember more of their lecture (Damcott *et al*. 2000). MFL learners too are reported as finding that the multi-sensory input made learning more memorable (Thomas 2003).

Moreover, the facility of IWBs to present information in sharp colours, and to annotate, conceal, manipulate, move and zoom in on or focus on images, including text, is also said to enhance the learning process (Damcott *et al*. 2000; Bell 2002; Levy 2002; Thomas 2003). For example, manipulation and colour in visual images is argued to facilitate an understanding of fractions and percentages in relation to coloured squares in a shape, the measurement of angles, and the transformation of shapes (Edwards *et al*. 2002). Unlike most of the reported benefits of IWBs as a teaching tool, the literature does relate the unique physical and tactile nature of the boards with the reinforcement of pupils' learning, especially when pupils are allowed to interact with the board themselves (Clemens *et al*. 2001). Kinaesthetic learning is said to be due to 'ostensiveness', or the link between representation by imagery and perceptual organisation, so that 'the physical act of pointing and activating the screen, whether with a finger, a stylus, pen, or the mouse consolidates the topic being learned' (Virtual Learning 2003c, p. 1).

The capacity to present a range of multimedia resources efficiently is also argued to help pupils. This is not only because there is more information available, there is also a wider variety of information so that ideas and concepts become more 'tangible' and pupils find the concepts easier to 'grasp' (Levy 2002). For example, the facility of IWBs to combine sound with graphic and iconic visual images is claimed as particularly useful to learning about music (Wiggins & Ruthmann 2002). In addition, it is argued that IWBs accommodate a range of 'learning styles' as teachers are able to call on whichever type of resource is suitable for particular pupils' needs (Glover & Miller 2001; Billard 2002; Bell 2002).

The basis of these claims about learning with multimedia and multi-sensory representations must be questioned, however. It is not certain whether verbal and visual information are always best presented together, and if dynamic visuals are always better at promoting understanding than static visuals. Recent research reveals that simply showing a process to a learner with the aid of dynamic visuals would not, 'miraculously produce understanding of that process' (Goldman 2003, p. 240). In fact it appears that the learning affordance of dynamic visuals depends more on the subject matter (i.e. specifically where understanding is harder to support with static visuals), and on the specific arrangement of visuals (static or dynamic) with verbal information in order to highlight important relationships and remove irrelevant information (Mayer 2003). This reasoning must also relate to the benefits of touching the board. It is debatable whether physical interaction with the board itself enhances learning, other than to motivate pupils to pay attention, unless the physical interaction is somehow directly relevant. For example, Greiffenhagen (2002) discusses the need for drawing lines and shapes in mathematics, so that there is a sense of 'direct manipulation' pertinent to understanding the properties of a shape. The value of identifying and targeting pupils' learning styles has also been comprehensively questioned (Coffield *et al*. 2004).

This provokes a further question: when does lots of information become too much information? Pupils in Levy's study (2002, p. 14) expressed concerns such as 'it can be confusing', and 'it is complicated to take in'. Seufert (2003, p. 228) presents evidence that the effective use of multiple representations in the construction of coherent knowledge often depends on students' prior knowledge of lesson material. Students with less experience of subject material tend to focus in on only one representation, 'often the more familiar or concrete one'.

In concluding this section, there does not appear to be empirical research evidence linking increased pupil attainment with use of IWBs for teaching and learning. In fact teachers at Richardson Primary School (Lee &

Boyle 2003) recognised the need to be 'very cautious about ascribing too much claim' to IWBs in their comprehensive review of the educational effects and implications of the placement of IWBs within their school.

Problems and issues

This final section reviews the concerns expressed by both teachers and pupils in terms of the problems and issues encountered when using IWBs in real-life educational settings.

Training and support

One of the most frequent issues raised by both teachers and pupils is the need for adequate training in order to use IWBs to their full potential. Teachers' inexperience in setting up equipment and in manipulating features on the board, leading to lesson disruption, was a concern for both teachers and pupils interviewed in Levy's study (2002). Interviews in Glover and Miller's study (2001, p. 261) found that initial training by companies and suppliers with their 'slick presentation and high-quality prepared materials' were successful in 'firing' teachers with initial enthusiasm (Glover & Miller 2001, p. 261). The long-term value of such training, however, remains more questionable, as one teacher interviewed by Walker (2003b, p. 2) put it, 'if you don't catch them at the start, provide support and show them how to use learning material, their enthusiasm quickly wanes.' Some researchers have highlighted that even when a teacher aims to use IWBs as a transformative pedagogic tool (Burden 2002), lack of practical and methodological training can impede and frustrate such aims (Malavet 1998; Greiffenhagen 2000).

Levy (2002) observed that teachers who were already confident ICT users tended to become enthusiastic 'early adopters', able to experiment and develop their own IWB use following initial training. Those teachers with less confidence and experience with ICT, however, were less able to be self-reliant, preferring instead more sustained and individual guidance on a 'need-to-know' basis (Granger *et al*. 2002), or as part of more structured continuing support, such as where more experienced users work alongside novices (Glover & Miller 2001).

Teachers also need support when technical difficulties arise immediately prior to and during lessons. There may be networking problems with slow log-on facility, or a slow or non-existent response from electronic pens, unresponsive or awkward to move images, and a lack of signal between individual slates and the board. (Levy 2002). In such instances, rapid 'troubleshooting' support is a priority.

Practicalities

Other commonly cited difficulties relate to the practicalities of placing IWB equipment in classrooms. It is reported that pupils find it difficult, or even impossible, to see the screen on an IWB when sunlight is shining directly on it (Tameside MBC 2003). This has implications for the positioning of a board within a classroom and suggests the need for effective blinds (Levy 2002). Visual problems are compounded by the use of inappropriate colours and fonts and the presence of dust on the screen or projector lens (Levy 2002). Teachers report that they need to stand to the side of the board or a shadow is cast over the screen (Bell 2001; Walker 2003b), a difficulty also experienced by pupils (Smith 2001). Concern is often expressed regarding the health and safety implications of the multitude of wires required for IWBs and associated equipment (Bell 2001; Smith 2001; Tameside MBC 2003).

The height at which an IWB is placed can be an issue, particularly where boards are permanently fixed and if pupils are to use them (Tameside MBC 2003). If the board is placed too low on the wall the screen may not be seen by pupils at the back of the class and some functions may be difficult to operate (Canterbury 2003). If the board is placed too high, however, even teachers may have difficulty reaching the top (Tameside MBC 2003). The size of the screen is a related factor to consider (Damcott *et al*. 2000; Smith 2001). Many teachers also report difficulties in movement of the board or projector, especially when the board is not permanently fixed, as this causes the calibration to be disturbed requiring re-alignment: a major inconvenience if it happens every time a pupil tries to use the board (Bell 2001; Smith 2001; Tameside MBC 2003).

Levy (2002) shows that teachers' development with IWBs depends on easy and frequent access. There is little incentive for secondary school teachers to plan a

lesson with the board if they are faced with repeating the same lesson in a room without a board. Moreover, she found that teachers preferred to use their regular classroom rather than disrupt the class and move to another room, even if timetabled for IWB access (Levy 2002). Other research shows that teachers with IWBs in their classrooms made more positive comments regarding their use than those without such access (Glover & Miller 2001). Indeed it has been argued that use of IWBs as a 'transformative' device is only possible when they become part of the regular fabric of classroom life (Greiffenhagen 2000).

Conclusions

This review has revealed a clear preference for IWB use by both teachers and pupils. The government too, is keen to promote IWB technology. It remains unclear, however, as to whether such enthusiasm is being translated into effective and purposeful practice. IWBs are expensive, and as John (2002) points out, the technology is not standing still. Consequently, it could be argued that such technology should be used in unique and creative ways above and beyond that which is possible when teaching with normal whiteboards or other projection methods. As one commentator noted, 'in the hands of a teacher who is interested in developing the independent, creative, thinking skills of their students, (the IWB) will be used to further these purposes. . . . It's not what you use it's how you use it' (Virtual Learning 2003b, p. 4). We would argue that the uniqueness and the 'boon' of IWB technology lies in the possibility for an intersection between *technical* and *pedagogic* interactivity; in other words, in the opportunities this technology holds for collective meaning making through both dialogic interaction with one another, and physical interaction with the board.

In order for us to understand the best way for practitioners to use IWB technology in the future as transformational devices, research is needed in order to collect empirical evidence so that the processes of teaching and learning with this new technology are more fully understood and more coherently conceptualised. An interesting starting point for this research would be to ask what the intersection between *technical* and *pedagogic* interactivity looks like in reality.

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