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REVIEW ARTICLE

Reviewing the literature on interactive whiteboards

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The aims of this article are to review the existing literature on the introduction and use of interactive whiteboards (IWBs) in schools and to summarise the key issues arising from this analysis in order to provide a context for the articles which follow in this special issue of *Learning, Media and Technology*. The article reviews the evidence about the initial adoption of the technology in classrooms, the existing empirical evidence of its impact on teaching and learning in schools as well as presenting an analysis of some of the underlying theoretical and conceptual issues.

Introduction

There are a number of existing reviews of the literature about the use of interactive electronic whiteboards in educational settings (e.g. Glover *et al.*, 2005; Smith *et al.*, 2005). These have sought to identify the available literature about the use of such technology and describe the themes within this evidence base. In response to the initial critique in these reviews about the diversity of this literature and the limitations that this imposes on drawing clear inferences about the impact of interactive whiteboards (IWBs), the main aims of this article are to update these reviews to provide an additional analysis of a number of more recent publications about educational research involving IWBs and to take a critical stance about the emerging evidence about the impact of such technology on teaching and learning. This is in order to provide a context for the articles which follow in this special issue of *Learning, Media and Technology*. The content of the review is structured in three main sections. These detail first the potential of the technology as identified in the literature about the initial adoption of the technology in schools, second the pedagogical impact of IWBs on both teachers and pupils in classrooms and third the empirical evidence concerning learning and achievement.

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The introduction of IWBs in schools in the UK also provides a particular context in which this analysis is needed. The National Strategies in England have endorsed this technology and, although not statutory elsewhere in the UK, these strategies have influenced teaching strategies more widely (Tanner *et al.*, 2005; Condie & Munro, 2007). This has been promoted further by the financial investment of the devolved Welsh Assembly Government in placing at least one IWB in all schools, whilst many other schools in the UK have been provided with funding to invest in the technology (Miller *et al.*, 2004a; Armstrong *et al.*, 2005; Passey, 2006). In addition, the British Educational Communications and Technology Association (Becta) provides extensive advice about their purchase and use, and a further National Whiteboard Network (http://www.nwnet.org.uk/) offers advice and resources for practitioners. An overview of these initiatives is available though the England's Office for Standards in Education, Children's Services and Skills (Ofsted, 2004) and the uptake of the technology is noted in Becta's annual reviews (e.g. Becta, 2006). There is clearly an expectation that school teachers use IWBs in their lessons and an elision of the concept of the technical interactivity offered by the equipment with the development of more interactive teaching (Smith *et al.*, 2005). The introduction and uptake of IWBs and their impact on pedagogy is not just a UK phenomenon, however, and a similar picture is emerging internationally (e.g. Schuck & Kearney, 2007).

The adoption of IWBs in classrooms

IWB technology was initially developed for presentations in office settings and, in terms of educational settings, appears to have been used first in higher education (Murphy *et al.*, 1995; Stephens, 2000), with the potential for use in primary schools acknowledged in the late 1990s (Moseley *et al.*, 1999, p. 79). They might perhaps be more accurately called *electronic* or *digital* whiteboards, though an internet search indicates that the phrase *interactive whiteboard* outnumbers the others by a factor of nearly 5:1 and over 20:1, respectively. As earlier reviews have noted, much of the early literature has been descriptive. It details the introduction of new technology and therefore reflects the enthusiasm of the 'initial innovator' and 'early adopter' (Rogers, 1983) or 'missioner' (Glover & Miller, 2003) who had a vision of what the technology might achieve. It was characterised by being small scale, often using action research as a methodology and conducted by enthusiastic innovators (Cogill, 2003), sometimes amounting to personal testimony and advocacy as noted by Smith *et al.* (2005). It was, perhaps, indicative of the potential of the new technology in classrooms.

This potential was based on a number of affordances of the technology (Kennewell, 2001). A number of benefits were identified, such as that IWBs were well adapted to whole-class teaching (Glover & Miller, 2001a), particularly in terms of developing more effective demonstrations (Stephens, 2000), presenting a variety of representations (Kennewell & Beauchamp, 2003) and aspects of display more generally (Robison, 2000). All of which had the potential to meet the needs of a wider range of learners (Latham, 2002; Levy, 2002), as well as identifying issues

such as the wider impact of the technology in terms of classroom management. IWBs were identified as making it easier to incorporate and use a range of multimedia resources in lessons such as written text, pictures, video, sound, diagrams, online websites (Ekhami, 2002; Johnson, 2002; Levy, 2002). The resources created and presented are attractive to both teachers and children (Ball, 2003; Kennewell, 2004), and capture and hold pupils' attention much more strongly than other classroom resources (Smith *et al.*, 2005). One of the most widely claimed advantages of IWBs was that they were seen to motivate pupils, with resulting improvement in attention and behaviour (Beeland, 2002). IWBs were perceived as linking with the fashion for different learning styles (e.g. Ball, 2003). The interactive software available enabled teachers to model abstract ideas and concepts in new ways so that the pupils might respond to the activities and deepen their understanding (Edwards *et al.*, 2002; Richardson, 2002; Miller, 2003). They could quicken the pace of lessons through the use of prepared materials which reduced the need to write on the board (Glover & Miller, 2001b; Ball, 2003; Miller, 2003) and could smoothen lesson transitions (Latham, 2002; Ball, 2003). The facility to save and then re-use materials which have been created or annotated could reinforce and extend learning over a sequence of lessons (Glover & Miller, 2002; Walker, 2002). When connected to an intranet they could encourage resource sharing amongst staff which might reduce teacher workload (Kennewell, 2004). IWBs were considered to be relatively easy to use and therefore favoured by teachers (or the head teachers of teachers) who otherwise struggled to incorporate technology into their classrooms (Smith *et al.*, 2005).

The disadvantages or drawbacks identified tended to be of a practical or logistical nature. This was in terms of cost as IWBs can be more expensive to purchase than other presentation or display technologies which might share much of the same affordance; they could prove difficult to maintain and presented difficulties when out of use or when a teacher without the skills to use one was faced with one in the classroom; there were difficulties in placing them at the right height for use by both children and adults because of lighting or seating arrangements; mobile versions presented challenges in terms of setting up and maintaining (Brown, 2002; Smith *et al.*, 2005). It was also noted that, at least initially, preparation for lessons took longer, and it took time and experience to become technically accomplished (Glover & Miller, 2001c; Levy, 2002; Ball, 2003). Pupils reported that presentation of information could be 'confusing' Cogill (2003) and Knight *et al.* (2004) observed that IWBs are not necessarily used interactively. Indeed, without positive support, they argued that IWBs could reinforce a teacher-centred style of delivery. From this perspective, Beeland (2002) conducted an evaluative study of IWB use which found that the lessons where pupils were most positive about the use of IWBs were the lessons in which teachers made least use of the interactive potential of the technology and most use of their facility to present multimedia resources.

The terms in which both the potential of the technology and its disadvantages are described are reasonably consistent across the available body of this early work. These features were then summarised and endorsed in government literature devoted to the technology and made available on official websites (e.g. Becta, 2004), and there

appeared to be a growing consensus about the potential benefits of adopting such technology.

The enthusiasm generated by this phase of technology innovation was perhaps spurred on by the relatively disappointing impact resulting from pupils' use of computer technologies on attainment over the same period (Harrison *et al.*, 2002; Higgins, 2003), and supported the development of a number of policy-led initiatives to develop the use of IWBs in schools in the UK as a means to create 'schools for the future' or the 'embedding' of Information and Communication Technology (ICT) (Ofsted, 2004). This phase of reporting and research can perhaps be characterised as outlining the early promise of the new technology as it was incorporated into classrooms.

Models of teacher development

As the IWB became established in classrooms, researchers began to examine the process of teacher development associated with both the introduction of the IWB and the development of its use. This focussed on technical as well as pedagogical change, and included the position of pupils in this process of development and their own use of the technology.

A number of models or sequences of development for the use of the IWB are outlined in the literature. Davison and Pratt (2003) suggest a sequence of changing pupil and teacher participation patterns within the classroom involving teacher and pupil use of the board based on its visual and haptic affordances. In developing techniques for more effective use of the IWB in mathematics teaching, McCormick and Scrimshaw (2001) have indicated the need for a rapid movement along a continuum from more attractive presentation of materials, through developing increased pupil motivation, to the achievement of sustained and interactive learning approaches by the teachers involved. It is this element of interactivity that is now recognised as the key to both learning and sustained interest. This has two dimensions: first the interaction between pupils and teachers, pupils and pupils, and teachers and teachers as indicated by Birmingham *et al.* (2002); and second the interplay of digital information as elements in the learning process as evidenced by Buckley (2000), working within the field of biology education. Robison (2000) and Jones and Tanner (2002) offer evidence to show that interactivity is most effectively sustained through effective questioning as well as a wider range of activity.

Miller *et al.* (2004b) have provided evidence that effective pedagogical interactivity requires structured lesson planning, with stepped conceptual learning, pace in activities and a cognitive review, all of which offer opportunities for sustained use of a variety of IWB techniques. Keele University's two-year Nuffield-funded study of IWBs in secondary mathematics teaching combined a curriculum intervention, involving the development of software and pedagogical topic guides designed to exploit the interactive potential of the boards, with an evaluative study of these materials in use. Methods included classroom observation, teacher and pupil surveys and two attainment tests designed to assess the impact on pupil learning.

From their review of the data, Miller *et al.* (2004a) identified 'six common techniques, or "manipulations" that are used in the course of lessons with an IAW [interactive whiteboard] to enhance interactivity between teacher, material and pupils'. They listed these as drag and drop; hide and reveal; colour, shading and highlighting; matching equivalent terms; movement or animation; and immediate feedback.

In some lessons with an IWB, these techniques were used in a way which supported learning, but this was not always the case, and in a second paper the team concluded:

> In short it would appear that the effective use of the IAW in enhancing attainment hinges upon the progress made by teachers in harnessing the additional power of the technology to prompt analysis of the learning process in the teacher, and appreciation of the concepts and applications by the pupil. (Miller *et al.*, 2004a, p. 2)

Good teaching remains good teaching with or without the technology; the technology might enhance the pedagogy only if the teachers and pupils engaged with it and understood its potential in such a way that the technology is not seen as an end in itself but as another pedagogical means to achieve teaching and learning goals. The project concluded that reaching this point in use takes time. They conceptualised a three-stage process of pedagogical development in establishing effective teaching with IWB technology:

a. Supported didactic where the IAW is used to enhance traditional board focused didactic teaching…
b. Interactive where the teacher recognises some of the additional benefits of the technology and endeavours to stimulate interactivity by questioning and involvement of pupils…
c. Enhanced interactive where the teacher moves from the instructional to the involvement role and uses the technology to stimulate, integrate and develop interactive learning. (Miller *et al.*, 2004a, pp. 6–7)

The potential of developing pupils' IWB abilities and allowing them more involvement in classroom decisions can be allied to teacher development. Beauchamp (2004) proposes a transition framework based on research with primary school teachers, moving from the IWB as a substitute for a traditional blackboard or whiteboard through five stages to 'synergistic' use where 'both teachers and pupils are able to construct meaning and dictate the direction, momentum and scale of the next step in the lesson' (p. 344) across four dimensions of technical, mechanical, software and pedagogical competences.

Pedagogy of use

An important trend in the early reports is the change of focus from describing and exploring the affordances of the technology to consideration of the development of the pedagogy of use. Miller *et al.* (2004b) describe how this mirrors the process of technological change more broadly. As teachers become more fluent in their use of IWB and as they recognise the link to pedagogical change, the IWB becomes a potential catalyst for further change. Some features of this have been reviewed previously

(Glover *et al.*, 2005; Smith *et al.*, 2005), concerning the development of general and subject-specific techniques such as possible benefits from visualisation of concepts (Murphy *et al.*, 1995) and some requirements of pupils' questioning which might lead to more effective use of the technology (Olive, 2002).

Other evidence points to the potential pedagogical gains to be made from IWB use. Carr (1999) considers whole-class use of the technology and some of the constraints of classroom management which may occur. Cogill (2003) identifies some techniques that may enhance teaching effectiveness and Clemens *et al.* (2001) describe some benefits for learning when an IWB was used with very young low-attaining pupils. All these reports outline the link between the capacity of IWB technology to enliven presentation, increase pupil participation and reinforce learning. They consider the ways in which an IWB can be used to support pedagogy through interactivity though few authors are specific about how this can occur, and, as earlier reviews have noted, these reports have not been subject to peer-review and were often sponsored by the manufacturers of the equipment.

Armstrong *et al.* (2005) present the results of an Economic and Social Research Council (ESRC)-funded research project which aimed to capture, analyse and communicate the complex interactions between students, teachers and technology that occur in the classroom. Teachers and researchers used an innovative research design developed through the InterActive Education project (Sutherland *et al.*, 2004). Video case studies were carried out in four classrooms, focusing on the use of IWB technology for teaching and learning. The teachers involved developed coding systems with the research team drawing on the learning aims and objectives of their particular lessons. Their case studies illustrate that the introduction of IWBs into the classroom involves much more than the installation of the board and software. The researchers argue that teachers are critical agents in mediating the software and in ensuring the integration of the software into the subject aims of the lesson and the appropriate use of the technology to promote quality interactions and interactivity. They further argue that training and ongoing support is required for teachers to appropriately use such technology and to support their selection of appropriate software. Their conclusion is that the potential affordances of the IWB are often not realised.

There is increasing awareness that teaching is a multi-modal activity drawing upon a range of communicatory activities such as verbal, visual and interpersonal communication, as well as associated technologies. Jewitt (2002) has shown that knowledge of multi-modal perception and pedagogy can support both teachers and pupils. Abrahamson (2003) relates the development of mathematical cognition and the role of artefacts or bridging tools, including gesture in that learning process. Watson and De Geest (2005) outline the need for consideration of all aspects of communication in teaching and learning mathematics, and Rasmussen *et al.* (2004) explore the use of consistent gesture as part of these multi-modal approaches. Goldin-Meadow and Singer (2005) take these patterns of gesture further and consider the impact of these on both learners and their learning environment through reflection of the state of knowledge and subsequent change through cognitive understanding.

Technical and pedagogical interactivity

The link between pedagogy and use of IWBs has led to further exploration of the way in which interactivity can assist learning. Latane (2002) has suggested that interactivity with all technologies needs to be between pupil and pupil as well as between pupil and teacher; Glover and Miller (2002) have indicated the need for rapid feedback and the opportunity to explore ideas as an addition to enhanced presentation of material, and Iding (2000), working in initial teacher education for science teacher, has shown the need for the co-ordination of pictorial, textual and audio materials. Beauchamp and Parkinson (2005), discussing the value of IWB use in science teaching, argue that it is a combination of the features of the IWB which can foster interactivity and that this is also dependent upon particular subject goals.

Schmid (2006) contributes to the theoretical and methodological development of IWB research by developing and applying a critical theory of technology, which stresses the need to contextualise the use of technology by understanding its embeddedness in social practices when investigating its integration in any context. The data are drawn from a qualitative PhD study, which aimed to exploit the potential IWB technology for the teaching of English as a foreign language. The findings suggest that the developing picture of technology use in the context investigated was the result of the interaction of several elements, which included the inherent characteristics of the technology, the teacher's pedagogical beliefs and the students' own understandings of the potentials of the technology as well as the negotiations between the students and the teacher regarding how the technology should be pedagogically exploited.

Even in this work, however, there is not a clear distinction made between the way in which the technical interactive affordances (i.e. the enhanced facility for teacher or pupils to work with a range of digital materials and manipulate them on the touch-sensitive screen) and the way that these might intersect with the pedagogical interactive affordances (i.e. more effective interaction between teacher and learner or learners and learners that enhances the intended learning). An IWB may be technically interactive, but may lead to less interactive and more didactic teachings (Smith *et al.*, 2006). Conversely, less interactive use of the technology may increase interaction between the teacher and pupils or between pupils. This argument is developed in the study by Smith and Higgins (2006) where an analysis of a purposive sample of literacy and mathematics lessons from the 'Embedding ICT' research project described below (Higgins *et al.*, 2005) indicated the challenge of developing more interactive pedagogy which is based on the technical interactivity of the IWB. There is a potential connection between the technical affordances of the equipment and interactive teaching, but not a necessary one.

Empirical evidence about the impact of IWBs

More rigorous studies and larger scale research then began to emerge in the journals. At this stage, the indications from more systematic research were more ambiguous. Inherent in much of the early literature discussed above is the underlying belief, or

possibly assumption, that an IWB can have a positive effect not just on motivation, but also on learning. Alongside the research on classroom pedagogy and interactivity outlined above is a much smaller body of research which attempted to provide an empirical basis for such optimism.

Clemens *et al.* (2001), in an industry-sponsored study, had found measurable enhancement of low-attaining learners' performance at the beginning of their school career. Similarly Weimer's (2001) study of student attitudes and motivation adopted an experimental design and found clear benefits associated with the use of the IWB. Beeland's (2002) study, mentioned above, found that both teachers and students were positive about the technology, but that further research was needed to identify how to ensure that the increased motivation was translated into increased learning.

A large-scale evaluation of the impact of IWBs for the UK's Primary National Strategy's 'Embedding ICT' pilot project was conducted where IWBs were installed in all of the Year 5 and 6 classes in more than 70 primary schools in six regions of England (Higgins *et al.*, 2005). Descriptive data about the day-to-day use of the white-boards were collected for two six-week periods one year apart using online diary forms. The weekly records with data for about 100 teachers' reported use (representing about 8800 lessons in literacy and mathematics) indicate an increase from just over 66% of lessons in the first year of the project to 74% of lessons one year later. Reported use increased in all parts of lessons, and patterns of software use indicated that teachers were involved in developing or adapting resources more in the second year of the research, suggesting greater levels of confidence and skill in using the technology.

The project investigated the impact in terms of classroom interaction, reported in the study by Smith *et al.* (2006), where significant differences were found between lessons ($n = 184$) using IWBs and those not using. The IWB lessons contained more whole-class teaching and less group work, and this was true for both mathematics and literacy lessons. With regard to the frequency of discourse moves (Sinclair & Coulthard, 1975), the lessons involving IWBs had significantly more open questions, answers from pupils and evaluation by the teacher. All these three moves together (the typical Initiate-Respond-Feedback structure) contributed to a faster pace in the lessons with an IWB (an increase of 16% in total moves). The frequency of answering in IWB lessons was higher, but the percentage contribution of the answers to the lesson remained the same—in other words there were more but briefer answers in IWB lessons. The amount of evaluation by the teacher in IWB lessons increased, along with uptake of questioning (where teachers incorporate a pupil's response in a subsequent question) though presentations from pupils were less frequent in IWB lessons. No gender differences were found between lessons with an IWB and lessons where the technology was not used, and there was no interaction effect between gender, IWB use and subject taught. They conclude, 'While our findings support some of the claims being made for IWBs, they do not suggest a fundamental change in teachers' underlying pedagogy' (p. 454).

The research also investigated teachers' (Higgins *et al.*, 2004; Higgins, 2006) and pupils' perceptions (Hall & Higgins, 2005; Wall *et al.*, 2005). These were overwhelmingly positive, though the teachers were more inclined to think that IWBs benefited

pupils, and were beneficial for their own learning than the pupils themselves. In terms of impact on pupils' attainment, however, the IWBs appeared to have a negligible effect (Higgins *et al.*, 2005). A statistically significant difference in attainment mathematics and science was identified between a sample of 67 of the schools (with about 2900 pupils' national test results for 11-year olds) involved in the pilot project with a matched control group at the end of the first year of the project (though the effect sizes were extremely small: 0.10 for mathematics and 0.11 for science). At the end of two years, there were no significant differences between the IWB schools' test results and the schools in the comparison group.

The evaluation by Moss *et al.* (2007) of the extension of the policy for the expansion of the use of IWBs into secondary schools found similar results They reported that the Secondary Whiteboard Expansion (SWE) scheme substantially increased the number of IWBs in use in London secondary school core subject (English, mathematics and science) departments. But that their use varied according to the teachers and subject areas and that although the novelty of the technology was initially welcomed by pupils any increase in motivation appeared short-lived. Furthermore statistical analysis showed no impact on pupil performance in the first year in which departments were fully conversant with the new technology.

IWB: dilemmas and directions

The use of the IWB may be the most significant change in the classroom learning environment in the past decade and the relationship between multi-modal pedagogy, multi-modal technologies and gesture as part of our communications armoury is an emerging and increasingly investigated area of research into teaching and learning. Analytic work (e.g. Glover *et al.*, 2005; Smith *et al.*, 2006) has already shown that the introduction of IWBs has affected teaching and learning interactions. As Wood and Ashfield (2007) illustrate in their study of student teachers, it is the skill and professional knowledge of the teacher who mediates the interaction with pupils 'which is critical to the enhancement of the whole-class teaching and learning processes' (p. 1).

The key issue emerging from this analysis is that although the IWB may alter the way that learning takes place, and that the motivation of teachers and pupils may be increased, yet this may have no significant or measurable impact on achievement. The research literature has yet to demonstrate the direction that teachers need to move to ensure that the proven changes the IWB can bring about in classroom discourse and pedagogy are translated into similar and positive changes in learning.

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