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THE EFFECTS OF INTERACTIVE WHITEBOARDS (IWBs) ON STUDENT PERFORMANCE AND LEARNING: A LITERATURE REVIEW

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ABSTRACT

Many K-12 and higher-ed schools in both the United States and the United Kingdom have made a substantial investment in interactive whiteboard technology. Interactive whiteboards (IWBs) are generally perceived by students and teachers as a positive addition to the classroom learning environment. While there is support for links between IWBs and increases in student motivation, questions remain about the relationship between IWBs, student learning, and achievement. In this study a literature review was conducted to better understand the research to date in this area. Several common themes surfaced including the effect of IWBs on pedagogy, motivation, interaction, perception, learning, and achievement. In addition, the research suggests that these effects are related to contextual factors such as teacher training, teacher confidence, school culture, technical support, and lesson preparation and practice time. An IWB framework is suggested and directions for future research are also discussed.

INTRODUCTION

Interactive whiteboards (IWBs) are being integrated into many classrooms especially in Great Britain and the United States. Much of the research on IWB effects

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come from Great Britain as the technology is part of a $27 billion initiative to update all primary and secondary schools by 2015 (Schroeder, 2007). Common themes on IWBs include effects on perception, motivation, attention, behavior, level of interaction between student, teacher, and IWB, learning, pedagogy, and achievement. Early evidence suggests that IWBs can have a positive effect on teaching and learning (Glover, Miller, Averis, & Door, 2007); however, much of this evidence is anecdotal, or based on case studies making it difficult to generalize. Existing studies often employ methods such as focus groups, surveys, and interviews. However, more is needed in terms of quantitative, large sample studies. Where there is data, studies often contradict one another (Glover, Miller, Averis, & Door, 2005b; Higgins, Beauchamp, & Miller, 2007; Martin, 2007; Schuck & Kearney, 2007; Thompson & Flecknoe, 2003). In addition, research to date does not often take into account the context in which IWBs are used. Nor is this context considered in terms of how it may affect student outcomes related to IWB usage in the classroom. Common contextual factors discussed in the current body of work include school culture, technical support, teacher training, teacher confidence, and time for teachers to prepare and practice lessons (Schuck & Kearney, 2007). Contextual factors are important to consider as they help to explain the direct and indirect links between IWB usage and student learning and performance.

Current research also suggests that IWBs are used to reinforce current didactic teaching practices, as teachers can easily use them as a blackboard replacement (Schuck & Kearney, 2007). It has been noted that in order for IWB use to have the greatest impact, there is a need for pedagogic change from the didactic to the interactive (Miller, Glover, & Averis, 2004). If teachers are unaware of the features of an IWB and how they link to an interactive pedagogy, often times the IWB becomes nothing more than a technological teaching aid (Glover et al., 2007). IWBs offer a whole new approach to pedagogy, but incorporating them into traditional didactic teaching styles can often be accomplished easily, and with little training (Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson, 2005). The fact that IWBs are not considered a disruptive technology is both a weakness and a strength (Schuck & Kearney, 2007). They can easily be integrated into traditional pedagogy, and thus be seen as a positive addition to the classroom. However, without a progression to an interactive pedagogy, long-term motivational and achievement gains are often not realized (Higgins et al., 2007). There is much more to the effective use of IWBs than simply ensuring that teachers have access to the equipment (Glover, Miller, Averis, & Door, 2005a). It is the context in which IWBs are integrated into the classroom that could have the greatest effect.

As a result of the extensive literature review, a suggested framework in which to consider the context and outcomes of IWB usage has been developed in this article. It is detailed in Figure 1. The framework is comprised of sets of variables: Environmental Factors, Interactive Whiteboard Usage, and Student

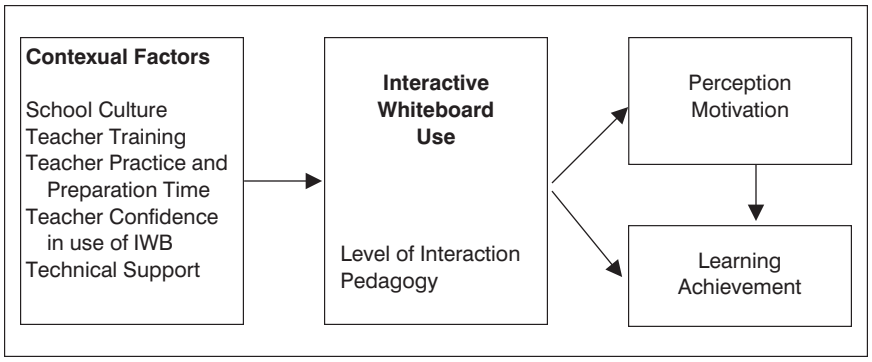

Figure 1. IWB framework.

Outcomes. The framework suggests that the level contextual factors influence how much interactive use of IWBs occurs and the extent to which this interaction is used in pedagogy. This interaction level and pedagogy in turn influences outcomes that are both socio-emotional and include perception and motivation as well as performance based and include learning and achievement. The links between contextual factors and student outcomes is discussed in detail.

Interactive Whiteboards Overview

IWBs were originally developed for office settings and are a relatively new addition to education (Smith, Higgins, Wall, & Miller, 2005). IWBs, sometimes referred to as electronic whiteboards or SMART Boards, are devices that connect to a computer, which in turn are connected to a multimedia projector. The computer image is projected on the IWB by the projector, and the user can control and manipulate this projected image through software installed on the computer. Similar to the way in which PDAs or smartphones are calibrated, an IWB must be oriented so that where the user presses on the board, is accurately represented on the screen. Some boards, such as the SMART Board, are touch-sensitive, and others rely on an invisibly gridded whiteboard and an electronic pen. Another type of technology that falls under the IWB category is the eBeam. This technology consists of a receiver placed on the edge of a flat surface, and a radio-wave emitting pen. The position of the pen with respect to the receiver is calculated by the computer, thus allowing the pen to accurately represent the mouse location on the flat surface. While this technology is less reliable than traditional IWBs, it is less expensive and more portable (Slay, Siebörger, & Hodgkinson-Williams, 2008). The lower cost along with its portability make the eBeam an attractive option for schools that want to integrate IWB technology, but may not have the necessary funds for a more expensive and permanent solution (Slay et al., 2008).

Most IWBs have two modes: computer control mode and writing mode. When the IWB is in computer control mode, a pen, or stylus, acts as the mouse, and a tap as a mouse click. In writing mode, the pen, or stylus, acts as an actual writing implement, with the computer producing digital ink on the projected image. Applications of the IWB are dependent on the software that is installed and used on the computer connected to the IWB. Some of the many applications available include hiding and revealing, writing and manipulating text, handwriting recognition, saving, retrieving, and printing notes, capturing and manipulating web content, shading, coloring, and animation. In addition, more recent SMART Board software allows the teacher to connect over the Internet to a library of subject-specific flash content like a virtual calculator, virtual frog dissector, interactive maps, and more. Many libraries are located at the IWB manufacturer's website, so that content can be added on a regular basis, giving teachers more options.

CONTEXTUAL FACTORS

Certain factors play a major role in how IWBs are used in education and are sometimes called "contextual factors" (Schuck & Kearney, 2007). Schuck found that the most common contextual factors include school culture, teacher training, time to practice and prepare materials, teacher confidence, and technical support. Other contextual factors to consider involve classroom setup and quality of equipment (Higgins et al., 2007; Smith et al., 2005). The level at which school districts or universities act on such factors varies, but the research shows that these factors play a major role in the effects of IWB use (Schuck & Kearney, 2007).

Many studies performed on IWBs do not include contextual variables such as the studies performed in London schools involved with the Secondary Whiteboard Expansion Project. Some discuss a limited number of contextual factors, and these factors are often not quantified, such as the level of interaction and teacher training. Therefore, the results of such research are often difficult to generalize. A detailed listing of papers that included contextual factors can be found in Appendix A, Table 1.

School Culture

School culture has an impact on other contextual factors (Schuck & Kearny, 2007). In schools that have an IWB culture, the importance of teacher training, practice and development time, teacher confidence, and technical support is often realized (Schuck & Kearney, 2007). A school led by a principal with an enthusiasm for technology, and one that supports innovation, is essential if IWBs are to be seen as an integral part of classroom pedagogy (Schuck & Kearny, 2007). A whole-school approach and senior management teams that support teachers by giving them the necessary resources to integrate IWBs into their teaching is necessary for creating an IWB culture (Glover et al., 2005a, 2007). In addition, an open and supportive parent-teacher culture coupled with interested students and

expectation of IWB use by teachers has also been noted as critical (Schuck & Kearney, 2007). A whole-school approach might include easy access to the Internet, as well as computer servers where documents can be easily saved, retrieved, and shared by teachers (Lewin, Somekh, & Steadman, 2008).

Teacher Training

Teacher training and professional development is essential for the effective use of IWBs (Armstrong et al. 2005; Glover et al., 2005a, 2005b, 2007; Hall & Higgins, 2005; Lewin et al., 2008; Miller et al., 2004; Schuck & Kearney, 2007; Shenton & Pagett, 2007; Slay et al., 2008; Smith, Hardman, & Higgins, 2006; Smith et al., 2005; Thompson & Flecknoe, 2003; Wall, Higgins, & Smith, 2005; Wood & Ashfield, 2008). Teacher training can be done on an as-needed basis with self-selecting teachers. However, as with school culture, teacher training on a whole school approach may be best. A whole school approach to training means that teachers will be more likely to engage in the technology (Armstrong et al., 2005) and help teachers to develop fluency (Glover et al., 2007).

Hall and Higgins (2005) note that professional development also needs to be ongoing. It is easy for schools to fall into the trap of acquiring IWBs, installing them, and then offering a one time technical training to teachers. Some schools may not even offer formal training at all. Teachers may be initially interested, and some may continue to develop skills on their own, but unfortunately this type of training program is common but not likely to result in the effective use of IWBs. Technical training is necessary, but training should go beyond the device itself. Teachers need to also be trained in how to integrate the IWB into pedagogy (Lewin et al., 2008; Schuck & Kearney, 2007; Shenton & Pagett, 2007; Smith et al., 2006). This pedagogical training should include how the IWB can be used to teach to different learning styles (Miller et al., 2004), and how an interactive multimodal approach may change their current pedagogic practices (Shenton & Pagett, 2007).

Other areas that schools might incorporate into an IWB professional development program are observation, coaching, feedback, and sympathetic discussion groups (Smith et al., 2006). A school culture that reflects a wide "buy-in" from teachers to the IWB concept will allow administrators and faculty to observe, coach, and give constructive feedback to each other (Smith et al., 2006). A sympathetic support group can help to build a sense of community and be a place for teachers to go to share their experiences (Smith et al., 2006). By giving teachers the proper ongoing technical and pedagogic IWB training, they are likely to be better equipped to transform their teaching as compared to their relatively inexperienced counterparts (Lewin et al., 2008). However, developing the necessary skill set is only one of many contextual factors that need to be considered. Teachers also need the time to practice and develop these skills, which in turn may give them the confidence to put them into practice (Shenton & Pagett, 2007).

Time and Teacher Confidence

If teachers are given the time to practice IWB usage, develop their IWB skills, and prepare materials in conjunction with IWB features, then IWBs may not be considered a disruptive technology (Schuck & Kearney, 2007). Formally giving teachers time to explore the IWB can produce better results and aid in creating an IWB culture (Schuck & Kearney, 2007). This might be accomplished by giving teachers a reduced teaching load, paying them overtime, or giving them in-service credits toward promotion. However, there is a trade-off in terms of time spent on learning the IWB and time spent in other teaching-related activities. If a school is to develop an IWB culture, then the total cost of an ongoing IWB professional development program might include time as an expense. It is only with time that teachers will develop fluency and confidence in using the IWB (Shenton & Pagett, 2007). Expanding on the total school "buy-in" concept, time also needs to be given to expert practitioners who can provide continuous feedback to their colleagues (Smith et al., 2006). In addition to giving teachers time to develop and practice their skills, teachers need time to develop IWB materials (Glover et al., 2005b; Miller et al., 2004; Schuck & Kearney, 2007; Shenton & Pagett, 2007; Wood & Ashfield, 2008). These materials could then be shared among other teachers within the school (Glover et al., 2007), who would then need more time to review them. Giving teachers time to practice, develop, and create will help in building and maintaining an IWB culture. With the proper ongoing professional development program and extensive time, teachers will be more likely to develop fluency and become more confident in IWB use (Shenton & Pagett, 2007). As teacher confidence increases, their lessons have greater impact (Miller et al., 2004). Confident use of IWBs is important, especially since students are keenly aware of the IWB abilities of their teachers (Slay et al., 2008).

Technical Support

Technical support is a critical contextual factor for a successful IWB implementation (Glover et al., 2005a, 2005b; Schuck & Kearny, 2007; Thompson & Flecknoe, 2003). Hall and Higgins (2005) note that students do not like technical problems, which from their perspective cause disruption, delay, and frustration. Technical problems are many times unavoidable and unforeseeable, but by setting up a routine technology maintenance program (Miller et al., 2004), perhaps some of these issues may be avoided.

Other Contextual Factors

In addition to the main contextual factors previously discussed, there are a few other factors to consider. These include regular access to the technology (Armstrong et al., 2005; Schuck & Kearney, 2007; Smith et al., 2005; Solvie,

2007), proper room arrangement and visibility (Glover et al., 2005b; Higgins et al., 2007), proper IWB height for both teachers and students (Higgins et al., 2007; Smith et al., 2005), and proper classroom lighting (Smith et al., 2005). Room design should be carefully considered prior to installing an IWB. Line of sight tests should be done and seats should be arranged so that students have easy access to the board. The brightness of the image cast by the projector should also be tested, and necessary room darkening equipment installed. This may include blinds over windows, or the ability to turn off banks of lights within the room.

Two factors that were not contained in the literature review, but should be considered are consistency of equipment, and access to regular whiteboards. When possible, school districts and universities should standardize on equipment installed in their classrooms. This standardization should include one type of IWB and software to control it, a common computer manufacturer and related software, and a common multimedia projector manufacturer. This will aid in creating a consistent environment for teachers, and help in creating an IWB culture. When teachers move from room to room, the equipment will look and feel the same, and user technical problems will be minimized. Providing standard whiteboards in an IWB classroom is also important. Teachers often need a traditional whiteboard in addition to the IWB for their lessons, especially for information that needs to remain visible for the entire class period. Traditional whiteboards can also serve as a backup, for occasions when there is a technical problem with the IWB setup.

Summary—Contextual Factors

The contextual factors of school culture, teacher training, time to practice, teacher confidence, and technical support are important for researchers to consider when studying how IWBs are used in schools. Building a school culture that supports interactivity and technical innovation sets the groundwork for an IWB implementation (Schuck & Kearney, 2007). School culture, like other kinds of organizational culture, arises from leadership attitudes and behaviors. The school culture should include a commitment toward teacher training, time to practice, and technical support all of which work together in forming an IWB school culture.

INTERACTIVE WHITEBOARDS: EFFECTS

In this study, consistent themes emerged regarding the effects of IWBs. The effect of IWBs on perception, motivation, attention, behavior, level of interaction, learning, pedagogy, and achievement were most prevalent. Appendix B, Tables 1 through 6, contains an extensive detailed summary of research findings on IWB effects from the literature reviewed for this study.

Much of the literature reviewed was specific to K-12 environment. Only one study, Schroeder (2007), considered IWB effects in higher education. The fact that little was found in the area of higher education is discussed further in the section on directions for future research.

Perception

There is some agreement that students have a positive perception of the IWB (Armstrong et al., 2005; Glover et al., 2005b; Martin, 2007; Miller et al., 2004; Schuck & Kearney, 2007; Smith et al., 2005; Wall et al., 2005). However, questions remain as to whether this perception is simply related to the novelty factor (Glover et al., 2005b, 2007), or whether it is more long lasting. Many of the studies in this review were not longitudinal, and were done shortly after the IWB has been introduced to the school. Therefore, the novelty factor could have been a strong influence. Glover et al. (2007) note that, "It is only when basic technological fluency and pedagogic understanding have been achieved that teachers can overcome the novelty factor" (p. 17).

There is also a perception that the use of IWBs will positively effect student achievement (Slay et al., 2008). While this will be discussed further on, it should be noted that while this perception exists, it is without much empirical support. Claims have also been made that IWBs promote an interactive class (Smith et al., 2006); however, it has also been noted that, "in many ways, the functionality of the IWB can be viewed as a modern technological version of a traditional blackboard" (Wood & Ashfield, 2008, p. 94). Schuck and Kearney (2007) state that lessons using IWBs were perceived as "better than" other class work. They relate this to the fact that IWBs can be perceived as easy to use, visual, interactive, immediate, and matching the students' digital culture. Lastly, students are aware of a teacher's confidence and ability using an IWB (Slay et al., 2008). If teachers lack confidence and ability, perceptions can change, and IWBs can be perceived as just another presentational 'gimmick' (Glover et al., 2005b).

Motivation, Attention, and Behavior

Motivation, attention, and behavior represent an overall student attitude in the classroom. There is some agreement that IWBs have a positive effect on student motivation (Armstrong et al., 2005; Glover et al., 2005b, 2007; Hall & Higgins, 2005; Higgins et al., 2007; Lewin et al., 2008; Martin, 2007; Schmid, 2006; Schroeder, 2007; Schuck & Kearney, 2007; Shenton & Pagett, 2007; Slay et al., 2008; Smith et al., 2006; Smith et al., 2005; Thompson et al., 2003; Wall et al., 2005; Weimer, 2001; Wood & Ashfield, 2008). Some caution that that heightened motivation correlated with IWBs may be due to the novelty factor and may decrease over time (Schuck & Kearney, 2007; Slay et al., 2008; Smith et al., 2005; Thompson & Flecknoe, 2003; Weimer, 2001), especially if the IWB is

overused (Schroeder, 2007). Some schools in the London Secondary Whiteboard Expansion Project reported that even where teachers were using the board in various ways, the increase in motivation was short-lived. Slay et al. (2008) caution that pedagogic value is of significant importance in maintaining motivational effects. To maximize student motivation, IWBs are best used in subject-specific ways, and should be embedded into teaching and learning (Martin, 2007).

The extent to which there is interaction with the IWB influences the effects of the IWB on motivation, attention, and behavior. It has been noted that at the *enhanced interactivity* stage (see next section), behavior problems can be overcome (Glover et al., 2005a). If students interact with the board themselves, motivation and attention can also be increased. It has been reported that IWB use in the K-12 sector promotes student interest and higher levels of sustained concentration (Glover et al., 2007). Some relate this to the multimedia aspects of the IWB, and that presentations are more visually stimulating (Hall & Higgins, 2005; Slay et al., 2008). This visual appeal is noted as one of the main contributors to motivation (Smith et al., 2006). Teachers can also benefit from the motivational effect of IWBs as some have reported that the technology has renewed part of their enthusiasm for teaching (Schuck & Kearney, 2007). Motivation still largely depends on the overall quality of teaching (Schroeder, 2007), not simply on a piece of technology. Support was found for a positive relationship between IWBs and attitude. However, some studies found that attention to task did not significantly improve even though students seemed enthusiastic (Solvie, 2007).

Level of Interaction

Interaction is a significant factor in sustaining student motivation and interest (Glover et al., 2005b; Higgins et al., 2007; Smith et al., 2005). However, IWBs are not always used interactively and can reinforce teacher-centered instruction (Higgins et al., 2007). As stated earlier, the literature to date reflects IWBs as a relatively non-disruptive technology and can easily be used as a blackboard replacement. Slay et al. (2008) mention that when IWBs are used in traditional ways, the value of the IWB can be attributed simply to the use of a data projector and computer. For some teachers, interactivity is not as important as the display of course content in multimedia modes. In addition, teachers report one of the main benefits as the ability to stay in front of the class while interacting with the multimedia course content. Interactivity needs to exist between teachers and students, students and students, and teachers and teachers (Glover et al., 2005b). Many teachers have a tendency to dominate the IWB lesson, simply use it for interactive whole class discussions, and not invite the students to interact with the board themselves (Schuck & Kearney, 2007). IWBs have limited impact when teachers do not realize that interactivity also requires a new approach to pedagogy (Armstrong et al., 2005).

In one study, primary teachers emphasize the tactile nature of the IWB and report that students and teachers should be interacting with the IWB (Schuck & Kearney, 2007). This was found to be a common theme (Shenton & Pagett, 2007; Smith et al., 2005; Thompson & Flecknoe, 2003). However teachers do not always follow this approach (Higgins et al., 2007; Smith et al., 2005). Teachers need to use appropriate software that enhances student interaction (Armstrong et al., 2005). One example is discussed by Thompson & Flecknoe (2003) where a software product called Easiteach Maths was used. This software was designed to bring students to the IWB, more directly involving them in the lesson. They found that the IWB works best when used interactively, especially when students interact with the board themselves. Good quality IWB software could be a good option for teachers to incorporate interaction into pedagogy. While children often want to interact with the board, it has been noted, however, that older students are not as eager to leave their seats as younger students (Smith et al., 2005). This finding has implications for the higher education sector and will be discussed later in this study.

According to Glover, teachers who set out to use the IWB progress through three stages of interactivity (Glover et al., 2005a, 2007). Stage one is called the *supported didactic* stage. At this stage, the IWB is used as visual support, and is not pedagogically integrated into lessons. This may cause the IWB to be seen as a novelty over time. The second stage is called the *interactive stage*. This stage is a progression from the *supported didactic* stage in that a variety of stimuli are used to illustrate, develop, and test discrete concepts. The IWB becomes the focal point of the lesson and demands attention from the students. The findings show that teachers still show an occasional lack of confidence, but still search for new approaches to pedagogy. At this stage teachers are more excited and share their experiences with other teachers. The third stage is called the *enhanced interactivity* stage, where the teacher looks to integrate concept and cognitive development in a way that exploits the interactive capacity of the IWB. The IWB is used to prompt discussions, explain processes, develop hypotheses, and test these by varied application (Glover et al., 2005a). This stage requires careful lesson preparation including verbal, visual, and kinesthetic activities. It also involves learning management, the ability to store and edit lessons, and the willingness for pedagogic change (Glover et al., 2007). Teachers are the critical agents in mediating the IWB software and the IWB hardware to promote interactions and interactivity (Higgins et al., 2007). The *enhanced interactivity* stage is needed for IWB use to have the greatest impact on teaching and learning (Glover et al., 2005a, 2007).

Learning

IWBs offer the opportunity to better match learning to different student learning styles (Glover et al., 2005a, 2005b, 2007; Schuck & Kearney, 2007;

Slay et al., 2008; Thompson & Flecknoe, 2003; Wall et al., 2005; Weimer, 2001). These learning styles include the kinesthetic, visual, audio, active, and verbal-social. There are, however, to date no absolute properties of an IWB have been identified that would allow one to predict the effects they have on learning (Armstrong et al., 2005), and the use of IWBs alone cannot lead to enhanced learning (Glover et al., 2007). In fact, it is not clear as to how IWB use might affect learning outcomes or concept development (Schuck & Kearney, 2007). This is partially due to the fact that many studies were done in schools where IWBs were a new addition to the classroom. A key factor to keep in mind is that IWBs are a mediating artifact. The teacher, not the technology, is still the most important element in student learning (Miller et al., 2004).

Some studies found there is limited impact of IWBs on cognitive learning (Martin, 2007; Miller et al., 2004; Schroeder, 2007), and that IWBs may alter the way learning takes place, but has not been shown to have a measurable impact on learning (Higgins et al., 2007). This finding is especially prevalent in studies where IWBs are found to be used as a blackboard replacement, and their effect on learning is negligible (Lewin et al., 2008). On the other hand, some studies show support for a link between IWB use and learning (Glover et al., 2005b; Schmid, 2006; Smith et al., 2005, 2006; Solvie, 2007; Thompson & Flecknoe, 2003; Wall et al., 2005; Wood & Ashfield, 2008), but do not differentiate between transferrable learning versus other kinds of learning (Martin, 2007; Mechling, Gast, & Krupa, 2007). So there are contradictions. However, the answer may lie in the type of learning domain under study. Some research suggests that the real impact of IWBs may lie in the affective domain, not the cognitive domain (Schroeder, 2007). While the cognitive domain focuses on knowledge and comprehension, the affective domain focuses on the learners' motivation, attention, emotions, self-concept, self-esteem, and social interaction in the learning environment. It is this type of learning that could be more important to learning and achievement (Weimer, 2001). It may be that IWBs can add a social dimension to learning where students can share knowledge publicly and learn by making mistakes together (Smith et al., 2006).

Pedagogy

Pedagogy is sometimes defined differently. For example, according to Lewin, pedagogy is defined as "the interactive process that goes on between teachers and children" (Lewin et al., 2008, p. 293). The Merriam-Webster dictionary defines pedagogy as, "the art, science, or profession of teaching." No matter the specific definition, one overall theme contained in the research reviewed is that effective teaching with IWBs requires pedagogy to contain an element of interactivity. Although IWBs are well adapted to whole-class teaching, when not used interactively, IWBs can reinforce teacher-centered styles of pedagogy (Armstrong et al., 2005; Schuck & Kearney, 2007; Smith et al., 2005, 2006). In

many cases, the underlying pedagogy of whole-class teaching remains unaffected (Wood & Ashfield, 2008). Many teachers have uncritically absorbed IWBs into their pre-IWB teaching practices (Smith et al., 2005). This can be attributed to the fact that IWBs are a non-disruptive technology (Schuck & Kearney, 2007). Effective pedagogical interactivity requires structured lesson planning, pace in activities, and a cognitive review (Higgins et al., 2007). The role of the teacher needs to change to one of a facilitator, which will allow more student exploration (Hall & Higgins, 2005). This may become a barrier in cases when the teacher wants to maintain a traditional didactic teaching style. It is also more difficult in Great Britain where many teachers are less open to involving their students in the lesson (Hall & Higgins, 2005). Teachers and students must work together rather than adopting the traditional formal roles of teacher and learner (Lewin et al., 2008). Without this pedagogical change, IWBs can be seen as a passing presentational aid or motivational spur (Glover et al., 2007).

Glover et al. (2007) report that early research focused on the benefits of the technology and not on how pedagogy may need to be changed. They go on to say that the starting point for changed pedagogy is teacher awareness and implementation of interactivity. Teachers need to reach the *enhanced interactivity* stage with regard to pedagogy. At this stage, there is an integration of technology, pedagogy, and learning styles. This stage can be obtained with the following changes to pedagogy: planning for cognitive development, clear visual representation of concepts, activities that encourage an active thinking approach, progression, illustration, sequencing, immediate feedback, and recall to strengthen learning (Glover et al., 2007).

Lewin et al. (2008) state that if IWBs are to have an impact, the IWB has to be seen as a mediating artifact. Teachers must allow students to interact with the board, and lesson plans need to be structured with associated resources accessible any time. Two effects of IWBs on pedagogy are that teachers are putting increased preparation time into their lessons, and they are spending more time thinking about students' individual learning styles (Schuck & Kearney, 2007). Lastly, teachers need to realize that students are keenly aware of any shortcomings in their teachers in relation to pedagogical uses of the IWB (Hall & Higgins, 2005; Slay et al., 2008). Teachers should practice their skills and develop confidence (Hall & Higgins, 2005; Martin, 2007; Miller et al., 2004; Schuck & Kearney, 2007; Slay et al., 2008). Teachers should also learn to teach creatively, by including a wide range of media such as video, animations, audio, graphics, animations and text (Wood & Ashfield, 2008) In addition, this creative teaching should contain relevant content for students to have ownership (Wood & Ashfield, 2008).

Achievement

There is some controversy as to the effects of IWB use and achievement. For the purposes of this literature review, the terms "achievement" and

"attainment" are used synonymously. While achievement can be defined as an accomplishment, and attainment can be defined as reaching a goal, they have similar connotations.

One of the most compelling studies that showed a negligible effect of IWB on achievement is Higgins et al. (2007). After a 2 year study, no significant differences were found in test scores between schools using IWBs, and schools not using IWBs. In addition, London schools in the Secondary Whiteboard Expansion Project, where teachers were using the IWB in various ways, reported no impact on pupil performance in the first year in which departments were fully conversant with the technology (Higgins et al., 2007). Schuck and Kearney (2007) also report that little or no difference was found on national test scores in mathematics and science in UK primary schools when comparing IWB and non-IWB classrooms. This apparent lack of effect on achievement is consistent with other studies contained in this review (Glover et al., 2005b; Martin, 2007; Smith et al., 2005; Solvie, 2007).

On the other hand, Lewin et al. (2008), note that positive gains were realized in literacy, mathematics, and science for children aged 7-11. These gains were directly related to the length of time that students had been taught using an IWB. In addition, these gains were stronger for children of average or above average prior attainment. There was negligible impact on prior low attaining pupils. Thompson & Flecknoe (2003) note that significant gains were realized using the ready made IWB program called *Easiteach Maths.* They reported a 14.1% improvement in attainment in the first term, a 22.1% improvement in the second term, and a 39.4% improvement overall. All children, regardless of prior attainment levels, made similar gains. It should be noted that *Easiteach Maths* is a highly interactive software package that involves students directly by having them use the board themselves (Thompson & Flecknoe, 2003).

Other research suggests that dialogic teaching, or whole-class interactive teaching, can lead to higher achievement (Smith et al., 2006). However, dialogic teaching can be accomplished with traditional teaching methods and basic use of the IWB. Motivation is one of the underlying factors in learning and achievement (Weimer, 2001). While findings generally showed that IWBs had a positive effect on motivation (Armstrong et al., 2005; Glover et al., 2005b, 2007; Hall & Higgins, 2005; Higgins et al., 2007; Lewin et al., 2008; Martin, 2007; Schmid, 2006; Schroeder, 2007; Schuck & Kearney, 2007; Shenton & Pagett, 2007; Slay et al., 2008; Smith et al., 2005, 2006; Thompson & Flecknoe, 2003; Wall et al., 2005; Weimer, 2001; Wood & Ashfield, 2008), there is not much research linking this increased motivation directly to achievement.

There is conflicting information regarding the effect of IWBs on student achievement and attainment. This presents a challenge and more research is needed using higher constraint research designs.

Effects Summary

Appendix B, Tables 1 through 6, contains a research summary of IWB effects on perception, motivation, level of interaction, learning, pedagogy, and achievement. In general, IWBs are perceived positively, and studies show they can have a positive impact on motivation. Whether this impact on perception and motivation is just a novelty factor, and will decrease over time, or one that is longer lasting seems to be dependent on pedagogy (Slay et al., 2008). By embedding IWBs and interactivity into teaching and learning, the motivational effect can be maximized (Martin, 2007). Sustaining this level of motivation and interest can be accomplished through quality interaction between teacher and student, student and student, and teacher and teacher. (Glover et al., 2005b). Some studies have also linked motivational effect to achievement (Weimer, 2001). Achievement has been reported by some to be positively impacted by IWBs (Lewin et al., 2008; Thompson & Flecknoe, 2003), while others see negligible impacts (Glover et al., 2005b; Higgins et al., 2007; Martin, 2007; Schuck & Kearney, 2007; Smith et al., 2005; Solvie, 2007).

Implementing an interactive pedagogy, teachers may acquire the knowledge on how to use the IWB to teach to different learning styles in the cognitive domain, and how to incorporate the social characteristics of the affective domain. Teachers should strive to reach the *enhanced interactivity* pedagogical stage and view the IWB as a mediating artifact. Perhaps the most cost effective and pedagogically effective way to incorporate IWBs into the classroom is to take a two-step approach. First, allow teachers to start with just a multimedia projector and a computer (Slay et al., 2008). Once teachers are comfortable with incorporating multimodal course materials into their pedagogy, they move to the next step, and add an IWB, along with interactivity. Some teachers may simply wish to use the presentational abilities of the computer and multimedia projector, keep their didactic teaching style, and not make changes to their pedagogy. Others may be willing to transform their teaching style from *supported didactic* to *enhanced interactivity*. The IWB will have the greatest effect in classrooms with teachers willing to make this transformation. It is important to remember that, "good teaching remains good teaching with or without the technology; the technology might enhance pedagogy only if the teachers and pupils engaged in 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" (Higgins et al., 2007, p. 217).

DISCUSSION—IWB FRAMEWORK MODEL

Based on the review of the literature it is posited that a more comprehensive framework is needed to understand the effects of IWBs in the classroom. In

the framework put forward (see Figure 1), the contextual factors of school culture, teacher training, time to practice, teacher confidence, and technical support combine to influence pedagogy and level of interaction which then effect perception, motivation, learning and achievement.

In order for IWBs to have their greatest positive influence on student learning and achievement, an interactive school culture is needed. A culture that embraces change and embodies a positive attitude or "buy in" to the idea of transforming teaching and learning through IWB use, provides the foundation on which the other parts of the framework are developed. If senior school officials are successful in providing a clear understanding as to what is involved in creating an interactive IWB culture, then positive IWB effects are more likely. The culture needs to be one that is shared by all school stakeholders including administrators, teachers, staff, students, and parents. To help in creating this culture, teachers need to be given the training and time to explore the IWB and its uses. This training should be both technical and pedagogical. The pedagogical training should be ongoing and assist teachers in transforming teaching through the three stages of interactivity (Glover et al., 2005a). Educational leadership must also factor in cost to implement the necessary framework. For IWBs to have the greatest effect on teaching and learning, the total cost of an implementation is likely to go beyond the cost of IWB equipment alone. Therefore, in order to develop the appropriate contextual factors necessary for successful IWB implementation, a "return on investment" (ROI) calculation needs to include these pieces as well.

Along with technical and pedagogical training teachers need time to practice and develop course materials. Transitioning to an interactive pedagogy will take time. As discussed, an interactive pedagogy is an important component if IWBs are to be maximized for learning and achievement. Allowing teachers to experiment with new ideas and to share these ideas with other teachers is also a key aspect of the framework. Having a collaborative and supportive environment should help in the transformation to an interactive pedagogy, but should also help in creating and maintaining an open IWB culture.

With proper training, preparation, and practice time, teachers are more likely to develop confidence in IWB use, which has been shown to affect long-term motivation and overcome the novelty factor. Students are highly cognizant of the technical and pedagogic abilities of their teachers and IWB use. If teachers reach the *enhanced interactivity* stage, then student motivation should be maintained over time. Without this level of confidence and pedagogical transformation, an IWB might simply be seen as a technological tool and not a mediating artifact. Whether it is in the cognitive domain, with IWBs lending to different learning styles, or the affective domain, with IWBs focusing on attitude, for IWBs to have the most effect, teachers should strive to be at the *enhanced interactivity* stage (Schuck & Kearney, 2007). Effective learning can be realized more fully when

teachers value the technology and fully understand the nature of interactivity and its pedagogic implications (Glover et al., 2007).

Providing teachers with timely technical support should help to maintain the open IWB culture. Technical support should include both a help desk for episodic problems as well as a regular maintenance program to help avoid issues. Teachers might be well trained and highly motivated; however, if the equipment doesn't work or breaks down regularly, the educational process could be negatively impacted.

The next part of the framework deals with the use of interactive whiteboards particularly with the level of interaction and pedagogy. The contextual factors influence these two mediating factors that in turn will play an important role in the extent to which the student's perception, motivation, learning and achievement are increased. A well-planned enhanced interactive pedagogy will have a greater effect than a traditional didactic pedagogy with respect to IWB use. Using an IWB as a blackboard replacement may have an initial beneficial effect, but the research to date has shown limited long-term benefit. Incorporating an IWB into existing pedagogy will not transform learning; it will only change how learning takes place. Without transforming learning, long term achievement gains are less likely to be realized.

This IWB framework is put forth based on the extensive literature review discussed in this study. While this framework may not account for all cases, it is put forth to help school leadership to begin the process of improving learning and achievement outcomes within the context of the many factors that have been found to be important contributors to success in these areas. The research is still in its early stages and, therefore, comparatively speaking, there are many studies that result in contradictory outcomes. Therefore, by extending a parsimonious framework from which explanatory power for varying results may be found, researchers may be able to further refine their investigations.

DIRECTIONS FOR FUTURE RESEARCH

There is still a tremendous amount of work that needs to be done with regard to the effects of IWBs on teaching and learning. Appendix C, Table 1, lists a summary of future research findings from the studies reviewed. Much of the research reviewed was done in the United Kingdom, a country that has invested a great deal of money to investigate how best to incorporate IWBs and information and communication technologies (ICT) into the classroom (Schroeder, 2007; Slay et al., 2008). More studies need to be done in the United States, where pedagogical practices vary and students are encouraged to participate more in lessons (Hall & Higgins, 2005).

There are many different ways in which the research has been done. All methods help to improve our understanding of the effects of IWBs on educational outcomes. However further defining the factors put forth in the IWB framework will help researchers more fully understand results as they relate to one another. It is hypothesized that the contextual factors discussed have a direct effect on the level of interaction and pedagogy used in the classroom, which in turn have an impact on perception, motivation, learning, and achievement. Perhaps the contextual factors posited here can be further quantified, which would aid in future data analysis performed on IWB impacts.

All but one of the studies listed in this review deal with the K-12 sector. More research is needed at the higher education level (Schroeder, 2007), as more investments in IWBs are made at this level. Institutions of higher learning often have varying school cultures, and professors who have differing approaches to pedagogy. It has also been reported that older students are not as eager to leave their seats (Smith et al., 2005), so this may have an impact on the level of interactivity that can be achieved. Class size could also be a consideration, as smaller seminar classes are quite different from larger lecture hall classes.

Future research should also focus beyond generic learning gains, and on subject-specific learning (Glover et al., 2005b; Schuck & Kearney, 2007), cross-curricular learning (Shenton & Pagett, 2007), and interdisciplinary learning. While some subject-specific research is available, it should be expanded. Future research in these areas should take the contextual factors and mediating variables posited here into account. Different demographic groups should also be considered when interpreting results.

A main theme in the literature is that many studies are carried out too soon after the technology has been introduced, and are not long term. Now that IWBs have been integrated into many schools over longer periods of time, studies can be revisited, and more longitudinal studies should be considered. These longitudinal studies could then also focus on the long-term impacts of IWBs on pedagogy, level of interaction, perception, motivation, learning, and achievement. As discussed previously, motivational effects could be attributed to the novelty factor, and future studies should attempt to address some of this issue. If, as reported by Weimer (2001), motivation is one of the underlying factors in learning and achievement, research in long-term motivation trends is critical. Taking this one step further, understanding how increased motivation due to IWB use is translated into learning, also needs to be addressed (Higgins et al., 2007).

There is a perception that an IWB implementation will, by itself, be motivating to both students and teachers, enhance interactivity, and increase student learning and achievement. As discussed, some studies have found that in many instances IWBs are used as blackboard replacements, and underlying pedagogy remains unchanged. Some studies find achievement gains, while others do not.

It would be beneficial to understand why this perception is so widespread, and to look at ways of correcting this view.

The added benefit of using an IWB interactively needs to be weighed against the benefits perceived by the school, its administrators, teachers, and students (Slay et al., 2008). Future research needs to be done in this area, and a return on investment (ROI) model should be created. This would benefit schools interested in IWBs, but may not have the resources necessary to properly address the required contextual factors discussed. Schools may be investing large amounts of money to install IWBs, and later find that the effects of these IWBs are related only to the computer, multimedia projector, and a change to a more multimodal pedagogy, not the IWB itself.

More research should also to be done on how IWBs impact different types of students, including special needs students, lower attaining students, average students, students with behavioral problems, and higher attaining students. This research could be done in subject specific areas, and at different grade levels. Gender, ethnic, cultural, socio-economic, and other demographic factors should also be taken into consideration and studied.

Mechling et al. (2007) mention an interesting area for future research where IWB technology should be compared to more traditional interactive methods such as flash cards. The idea of teaching with less expensive manipulatives is one that creates an interactive environment, but often does not require technology. Motivation, learning, and achievement gains should be studied comparing the use of IWBs and manipulatives.

An instrument that measures and assesses the impact of instructional methods needs to be developed and studied (Schroeder, 2007). This type of instrument would be beneficial to studying the impacts of IWB use. This instrument should also include a way to factor in the level at which contextual factors are addressed within a school.

Future research should also focus on the pedagogical progression from the *supported didactic* stage to the *interactive* stage to the *enhanced interactivity* stage. Investigating how one progresses and what is needed to accomplish this progression would be beneficial to both researchers and practitioners. The results could be used as a guideline for schools in creating an efficient training program for teachers. In addition to teachers who create their own IWB materials, there are a number of commercial products available. Research should consider these commercial software products and discuss their impacts and effectiveness more fully. Lastly, group and peer learning using IWBs should be further researched (Schuck & Kearney, 2007).

While there is a great deal of research available on the effects of IWB use in the classroom, a parsimonious model of the environmental or contextual factors will help to enhance researchers' understanding of the results. Future studies involving IWB impacts should report on the level in which contextual factors, such as the ones posited in the framework discussed, are addressed.

APPENDIX A
Table 1 – Contextual Factors

Author(s)	Year	Journal	Contextual Factors
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	A whole approach to training means that teachers will be more likely to engage in the technology and would then develop confidence. Long-term engagement is important. Regular access to IWBs is important.
Glover, Miller, Averis, & Door	2005a	Management in Education	Important factors include training opportunities, encouragement from senior leaders, availability of equipment, technical support, resource management, and ongoing professional development.
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	Time to prepare materials, training, access to software, proper room arrangement, good visibility, and technical support are necessary.
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	Missioners need to convince senior management to provide necessary resources. Whole-school professional development to help teachers develop fluency. Teachers should be able to share resources and software. Need to develop an IWB cultural within school.
Hall & Higgins	2005	Journal of Computer Assisted Learning	Need up-to-date equipment, training programs, continuing professional development, and technical support. Environment must allow for increased student access to the technology.
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	IWBs must be maintained, placed at the correct height for both teachers and students, have proper lighting and seating arrangements.
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	Need both technical and pedagogical training. Total school buy-in is needed including access to school servers and the Internet.

APPENDIX A (Cont'd.)

Author(s)	Year	Journal	Contextual Factors
Martin	2007	Literacy	
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	To maximize the use of IWBs as a positive influence on teaching, four factors must be considered: technological fluency, a range of IWB materials, classroom management skills to maximize the attention span of students, and an awareness if the complex interaction of teaching and learning styles. Also need technology maintenance, staff development and materials development.
Schmid	2006	Computer Assisted Language Learning	
Schroeder	2007	Communications in Information Literacy	
Schuck & Kearney	2007	Study done at The University of Technology Sydney	Need the following factors: a principal with enthusiasm for the technology, interest of the students in the technology, a school culture that has a supportive and open staff and parent culture, as well as an expectation that teachers would use the IWB, professional development by the school and commercial IWB suppliers, and time for teachers to develop their skills and to prepare materials. Professional development should focus on the IWB and pedagogy, not just on technical training. Technical support and easy access to IWBs is essential. Teachers should share their resources.

Shenton & Pagett	2007	Literacy	Good software that accompanies the IWB is important. In-service training is important. Teachers need time in preparing materials. Teachers need to become confident users. Training should focus on pedagogical skills, not just technical confidence.
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	Type of technology is important to mention, as interactive pen-based systems are cheaper and more portable, but less reliable. Other factors include screen visibility, IWB competency, value of multimedia content, motivation of teacher, and cost. Teachers must continue to practice the skills they have acquired from previous training classes. They need time to engage with the technology.
Smith, Hardman, & Higgins	2006	British Educational Research Journal	Professional development is needed encouraging changing pedagogic understanding and practices. Teachers need extensive time to try out these new practices and get feedback from expert practitioners. Professional development should also include observation, coaching, sympathetic discussion groups, and feedback.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	Training and support are essential. Proper viewing is essential consisting of items such as limiting sunlight, board height, and clean screens and lenses. Using a good color and font scheme in IWB materials is also important to proper viewing. Teachers must have frequent access to the technology, and this access should be in their own classroom.
Solvie	2007	Educational Philosophy and Theory	Teacher innovation is important, as well as IWB specific software. Having them readily available in a standard classroom is also important.

APPENDIX A (Cont'd.)

Author(s)	Year	Journal	Contextual Factors
Thompson & Flecknoe	2003	Management in Education	Technical support and teacher technical knowledge is important. Teachers need training in how to teach using IWBs and controlling the pace of lessons.
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	Teachers need process and curriculum-focused training, as well as training in how IWBs can affect students' understanding, remembering, and thinking.
Weimer	2001	SmarterKids.org research study	
Wood & Ashfield	2008	British Journal of Educational Technology	Teachers need time to develop resources for the IWB screen. Teachers need the technical ability, but must also have a clear understanding of children's learning and how this may be facilitated with whole-class lessons. Teachers should be involved in every step of the software development stage. The software shouldn't control the teacher; the teacher should control the software.

APPENDIX B
Table 1 – Perception

Author(s)	Year	Journal	Perception
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	Perception is Positive.
Glover, Miller, Averis, & Door	2005a	Management in Education	
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	Positive student perceptions. Some observers have raised concerns that the IWB can just be another presentational gimmick.
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	"It is only when basic technological fluency and pedagogic understanding have been achieved that teachers can overcome the novelty factor" (p. 17).
Hall & Higgins	2005	Journal of Computer Assisted Learning	Much has been claimed: greater interactivity, increased engagement, motivation and enjoyment, all leading to improvement is achievement. These claims have mostly come from manufacturers, policy makers and, academics. Need more input from students directly. Students like versatility, multimedia, and fun that IWBs provide. They also like the tactile elements of the board and being able to manipulate objects. Students don't like technical problems and not being able to see the board (sunlight).

APPENDIX B – Table 1 (Cont'd.)

Author(s)	Year	Journal	Perception
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	
Martin	2007	Literacy	Positive about the impact and potential of IWBs. This 'feel good' factor could be related to the Hawthorne Effect.
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	Teachers with access to IWBs are perceived by students to be twice as readily available to help during the course of a lesson, while teachers without access to IWBs follow more routing lessons with fewer collaborative activities. Students perceive their class as positive when teachers use the IWB well and are competent in its use. When only used on occasion, teachers seem to be more tentative and students lack confidence.
Schmid	2006	Computer Assisted Language Learning	Students perceive the IWB much more as a computer than a whiteboard.
Schroeder	2007	Communications in Information Literacy	Students value IWBs for their versatility, multimedia capabilities, and fun and games.

Schuck & Kearney	2007	Study done at The University of Technology Sydney	Teachers and students suggest that there is an improvement in lessons in which IWBs are used. Teachers, students, and school administrators feel IWBs are beneficial because they are easy to use, they are visual, interactive, immediate, and match to students' digital culture. Lessons using the IWB were perceived as 'better than' other classroom work.
Shenton & Pagett	2007	Literacy	
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	There is an assumption that IWB use will impact positively on learners' achievements. Students are aware of a teacher's confidence and ability using an IWB.
Smith, Hardman, & Higgins	2006	British Educational Research Journal	A claim made by commentators is that IWBs can promote an interactive class.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	Literature review states that evidence in many studies are in the form of surveys, interviews, and questionnaires related to teachers' and students' perceptions of IWB use. These are informal methods, so interpretations should be taken with caution. Also, the authors were unable to find any rigorous studies on IWB use and their impact on attainment and changes in classroom interaction. Literature states a clear preference for IWB use by both students and teachers.
Solvie	2007	Educational Philosophy and Theory	
Thompson & Flecknoe	2003	Management in Education	

APPENDIX B – Table 1 (Cont'd.)

Author(s)	Year	Journal	Perception
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	Overall comments are positive from students on the use of IWBs to teach the metacognitive process.
Weimer	2001	SmarterKids.org research study	
Wood & Ashfield	2008	British Journal of Educational Technology	"In many ways, the functionality of the IWB could be viewed as a modern technological version of a traditional blackboard" (p. 94).

APPENDIX B
Table 2 – Motivation / Attention / Behavior

Author(s)	Year	Journal	Motivation / Attention / Behavior
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	IWBs are motivational because pupils can interact with it.
Glover, Miller, Averis, & Door	2005a	Management in Education	At the enhanced interactivity stage, behavior problems are usually overcome due to sequence and pace of learning.
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	An improved and interesting presentation has a strong motivational effect. Motivational gains also help students with learning problems. Some literature shows a link between the capacity of the IWB technology to enliven presentation and motivate pupil participation.
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	IWB use in K-12 sector promotes student interest and more sustained concentration. Student motivation and understanding can be fostered for those with special education needs.
Hall & Higgins	2005	Journal of Computer Assisted Learning	Students say multimedia aspects of IWB hold their attention, increase their engagement and motivation.
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	IWBs are widely claimed to motivate students, resulting in improvement in attention and behavior. London schools in the Secondary Whiteboard Expansion project, where teachers used the boards in various ways, reported that an increase in motivation was short-lived.

APPENDIX B – Table 2 (Cont'd.)

Author(s)	Year	Journal	Motivation / Attention / Behavior
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	Improved enthusiasm and attention.
Martin	2007	Literacy	To maximize motivation, technology needs to be used in subject-specific ways and embedded in teaching and learning. Study noted little change in behavior of special needs children. Higher achieving girls participated most frequently in 'positive' behaviors followed by higher achieving boys. Positive effects on motivation were noted.
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	Group arrangement activity on a large interaction screen makes images more visible and increase attention to the task.
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	
Schmid	2006	Computer Assisted Language Learning	Students recognize the potential for IWBs to raise their motivation for sharing knowledge with their course mates by means of individual or group presentations.
Schroeder	2007	Communications in Information Literacy	The way in which information is presented on an IWB through the use of color and movement is seen by students to be motivating and reinforces concentration and attention. The novelty factor can diminish if used in every lesson, and much depends on the overall quality of teaching.

Schuck & Kearney	2007	Study done at The University of Technology Sydney	Students were generally on-task and motivated. Student motivation and engagement is enhanced. Motivation also relates to teachers as they look to present lessons in a more visually stimulating and interactive way. Teachers reported that IWBs had renewed their enthusiasm for teaching. In many cases, all of these findings could be at least partially attributable to the novelty effect.
Shenton & Pagett	2007	Literacy	IWBs are highly motivating to students and keep them on task.
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	Learners love to have technology as they can relate to it. This increases the motivational benefit of IWBs. Attention can wear off due to the novelty factor, which is why pedagogic value is of utmost importance.
Smith, Hardman, & Higgins	2006	British Educational Research Journal	Research suggests that *dialogic teaching* leads to different levels of participation and engagement. IWBs are motivating because of strong visual and conceptual appeal of the information displayed, and the physical interaction aspect. The widely claimed advantage with regard to motivation is that IWBs incorporate large visual images.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	Literature review has found that students are motivated in IWB lessons because of the high level of interaction and students enjoy interacting physically with the board by manipulating text and images. There are some concerns about the novelty factor with IWBs, as students become accustomed with its use. However, an experimental study showed that motivation improved in a class using an IWB.

APPENDIX B – Table 2 (Cont'd.)

Author(s)	Year	Journal	Motivation / Attention / Behavior
Solvie	2007	Educational Philosophy and Theory	IWBs allow the author to combine teacher modeling of literacy tasks with student involvement. The author imagined that by increasing students' attention, achievement would increase as well. This was not as successful as hoped. Student attention to task was not significantly improved during IWB lessons even though students appeared enthusiastic.
Thompson & Flecknoe	2003	Management in Education	Results show a crude indication that behavior did improve and that pupils were more motivated and on task during the lessons. Reductions in negative behavior were significant. Could be attributed to the novelty factor, but there was no noticeable decrease in enthusiasm over time. Over use of the IWB with little student interaction can lead to boredom and subsequent disruptive behavior.
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	Students believe that concentration was aided by the use of IWBs. Students were highly motivated, and this was indicated as a key factor impacting on the students' metacognitive process.
Weimer	2001	SmarterKids.org research study	Study to measure motivation impact suggests that motivation may be affected by the use of IWBs at least initially. It was difficult to determine if this effect is a temporary one. Motivation is an underlying factor in learning and achievement. There is some evidence of a relationship between student motivation and student performance.
Wood & Ashfield	2008	British Journal of Educational Technology	Previous research highlights the motivational impact of IWBs on students.

APPENDIX B
Table 3 – Level of Interaction

Author(s)	Year	Journal	Level of interaction
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	Teachers need to use the appropriate software that affords interaction and this may not be achieved if the IWB is seen as a presentation tool only. IWBs are least effective and have limited impact when teachers do not realize that interactivity requires a new approach to pedagogy.
Glover, Miller, Averis, & Door	2005a	Management in Education	3 stages are noted: *supported didactic* – IWB is used as visual support which causes students to see the IWB as a novelty, *interactive* – progression from *supported didactic* where a variety of stimuli are used to illustrate, develop, and test discrete concepts, evidence of occasional lack of confidence, full potential is not developed, enthusiasm is growing, *enhanced interactivity* – change of thinking, teacher looks to integrate concept and cognitive development in a way that exploits the interactive capacity of the technology.
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	Teaching can only be enhanced if interactivity is understood. Interactivity is recognized as the key to both learning and sustained interest. Interactivity needs to exist between teachers and students, students and students, and teachers and teachers.

APPENDIX B – Table 3 (Cont'd.)

Author(s)	Year	Journal	Level of interaction
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	Interactivity is most effectively sustained through effective questioning as well as a wider range of activity in lessons. Interactivity needs to be both teacher-student and student-student which may require a change in classroom practice. 3 stages are noted: *supported didactic* – IWB is used as visual support which causes students to see the IWB as a novelty, *interactive* – progression from *supported didactic* where a variety of stimuli are used to illustrate, develop, and test discrete concepts, evidence of occasional lack of confidence, full potential is not developed, enthusiasm is growing, *enhanced interactivity* – change of thinking, teacher looks to integrate concept and cognitive development in a way that exploits the interactive capacity of the technology. Enhanced interactivity can be achieved through lesson preparation (building on use of verbal, visual, and kinesthetic), lesson structure, learning management, storing and editing lessons, pedagogic change.
Hall & Higgins	2005	Learning, Media and Technology	The concept of interactivity needs to be accurately and operationally defined for teachers.
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	Many times IWBs are not used interactively, and can reinforce teacher-centered instruction. Interactivity is the key to both learning and sustained interest. Techniques to enhance interactivity include: drag and drop, hide and reveal, color, shading, highlighting, matching of equivalent terms, movement or animation, and immediate feedback. Teachers are the critical agents in mediating the software and using the technology to promote interactions and interactivity.

Lewin, Somekh, & Steadman	2008	Education & Information Technologies	
Martin	2007	Literacy	Literature states insufficient evidence to identify the actual impact of IWBs on learning in terms of classroom interaction.
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	Using IWBs as an adjunct, rather than an integrated element in teaching, minimizes interaction and the matching of teaching to the learning needs. The key to stimulating use of IWBs is a well-paced lesson that maximizes the interactivity of the board.
Schmid	2006	Computer Assisted Language Learning	
Schroeder	2007	Communications in Information Literacy	
Schuck & Kearney	2007	Study done at The University of Technology Sydney	Many primary teachers emphasized the tactile nature of the IWB. Students must be interacting with the board, not just the teacher. The ability to dynamically manipulate and annotate objects was stressed. Many teachers simply use the IWB in the form of interaction for whole class discussions. Observers found the main benefit from the board is not the ability to provide interactivity, but to prepare, organize, and store lessons with access to useful resources.

APPENDIX B – Table 3 (Cont'd.)

Author(s)	Year	Journal	Level of interaction
Shenton & Pagett	2007	Literacy	IWBs allow children and teachers to interact with it, but this will not necessarily promote an interactive style of teaching and learning. Many teachers have a tendency to dominate the whiteboard lesson, giving students few invitations to use the board themselves.
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	When used in traditional ways, the value of the IWB can be attributed simply to the use of a data projector and a computer. Interactivity per se did not seem as important as the multimedia display of course content. Some teachers view the IWB as a blackboard replacement where others view it as a support for interactive, participatory, and cooperative learning. The most recognized benefit of the IWB was the ability for teachers to stay in front of the class, a position of authority, while still interacting with the technology. This aids in proper classroom management (being in front of the class).
Smith, Hardman, & Higgins	2006	British Educational Research Journal	The idea of *dialogic teaching* should replace the terms of interactive or whole class teaching. A *dialogic classroom* has the essential features of being collective, reciprocal, and cumulative.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	Literature review has found that students are motivated in IWB lessons because of the high level of interaction and students enjoy interacting physically with the board by manipulating text and images. Evidence also suggests that not all teachers involve students to this extent. Involving students sometimes reduces the pace of the lessons and can cause boredom. Also some reports state that older students are not as eager to leave their seats as younger students. It is felt by some

			that IWBs increase student-teacher interaction, however, this can be done in other ways not involving the IWB. The quality of this interaction must also be addressed, not only the frequency.
Solvie	2007	Educational Philosophy and Theory	Critical engagement is possible if teachers move away from using IWBs as an attention getting device, to one of active student engagement in literacy activities.
Thompson & Flecknoe	2003	Management in Education	A study used a ready made application called *Easiteach Maths* which helps teachers deliver math lessons via the IWB. *Easiteach* was developed specifically to bring interactivity and greater student involvement to lessons by having students interact with the board. The board works best when used interactively, particularly when students use the boards themselves.
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	IWBs can be a valuable tool for teaching students about metacognition: thinking about learning. Students overwhelmingly want to be able to interact with the board themselves.
Weimer	2001	SmarterKids.org research study	
Wood & Ashfield	2008	British Journal of Educational Technology	In a case study, it was found that teachers did not seek to engage children in higher level thinking through discussion and interaction, and students took on a passive role. Opportunities for interaction and discussion were limited, and multimedia resources replaced the teacher.

APPENDIX B
Table 4 – Learning

Author(s)	Year	Journal	Learning
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	IWBs can be seen as interest enhancers instead of a new approach to learning. There are no absolute properties of the IWB that allow us to predict the effects it will have on learning. What students learn relates to how a technology is used in the classroom and teachers' and students' perceptions of how it can be used. Physical interaction with text and language is powerful to the learner.
Glover, Miller, Averis, & Door	2005a	Management in Education	IWBs offer flexibility, sequentiality, and the matching of learning to student learning styles.
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	Long-term learning gains outweigh management problems as teachers become increasingly more competent with the technology. Kinesthetic learning arises from movement, color, and the linkage of diagrams and verbal annotations in the development of concepts. The IWB has been used to link teaching and learning styles to student needs. Links are noted between the capacity of the IWB technology and its ability to reinforce learning. Interactivity and the nature of questioning have to change to optimize learning gains.
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	The use of IWB technology alone cannot lead to enhanced learning. IWB use in K-12 sector promotes more effective learning when technology is used to support variety of learning styles. Effective learning has been realized where teachers value the technology and fully understand the nature of interactivity and its pedagogic implications. Effective learning is inhibited where the IWB is given a novelty value by the teacher.

Hall & Higgins	2005	Journal of Computer Assisted Learning	
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	Interactivity can assist learning. IWBs may alter the way learning takes place, but really has no measurable impact.
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	IWBs have to be used and seen as a mediating artifact. If they are used as a glorified blackboard or as an occasionally animated passive whiteboard, then there will be little effect on student learning.
Martin	2007	Literacy	Literature states insufficient evidence to identify the actual impact of IWBs on learning in terms of classroom interaction or upon attainment and achievement. A study with interactive Big Books showed no pattern on writing performance. The Hawthorne Effect may have influenced results. Students did not transfer learning into their own work.
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	Study indicates increased correct reading and matching of word sets using *SMART Board* technology. Not sure if this learning is transferrable to new material.
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	Using IWBs as an adjunct, rather than an integrated element in teaching, minimizes interaction and the matching of teaching to the learning needs. In a study it was found that in terms of learning and understanding, student reaction suggests that the use of IWBs made no difference to their experience. This indicates that the teacher rather than the technology is the most important element.
Schmid	2006	Computer Assisted Language Learning	Study indicates that IWBs can be an effective tool for initiating and facilitating the learning process, especially where student participation is encouraged.

APPENDIX B – Table 4 (Cont'd.)

Author(s)	Year	Journal	Learning
Schroeder	2007	Communications in Information Literacy	Most studies do not show much of an increase in learning in cognitive areas; more often they point to increases in the *affective domain.* The *affective domain* focuses on learner's motivations, attention, and emotional response to learning. It also focuses on self-concept, self-esteem, and social interaction in the learning environment. Many studies show a positive impact on students' affective learning.
Schuck & Kearney	2007	Study done at The University of Technology Sydney	It is not yet clear how IWB use might affect learning outcomes or concept development. This is due to the fact that much of the research so far has been conducted in schools where IWBs are a recent addition, and not yet integrated into classroom practice. The versatility of the IWB makes it possible to cater to students with different backgrounds and learning styles. For IWBs to have a significant impact on teaching and learning outcomes, teachers must be at the *enhanced interactive* stage.
Shenton & Pagett	2007	Literacy	Some students claim that being able to move and interact with objects on the board helps them learn.
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	The IWB is seen as an effective tool for initiating and facilitating the learning process, especially when learners could use the IWB themselves. The time lost trying to diagnose technical problems and use the board properly can detract from the learning experience. It is argued that IWBs support a wider range of learning styles, but this is related to the variety of different resources available using the tool.

Smith, Hardman, & Higgins	2006	British Educational Research Journal	It is suggested that more interactive forms of whole class teaching will help in raising literacy and numeracy standards, thus raising learning performance. IWBs add a social dimension to learning where students can share knowledge publicly and learn by making mistakes together. Student interest in learning was enhanced because of the element of surprise that IWBs bring to lessons.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	There are two broad categories: IWBs as a tool for enhancing learning, and as a tool to support learning. IWBs provide for a more social constructivist view of learning where the teacher acts as the mediator between the students and the software. The literature does relate the physical and tactile nature of IWBs with the reinforcement of learning especially when students use the board themselves. However, it is debatable whether physical interaction itself enhances learning, other than to motivate students to pay more attention.
Solvie	2007	Educational Philosophy and Theory	The author found that by adding components engaging the students such as social interaction, student collaboration, strategy use, and support in decision making, continued use of the IWB engaged learning. Students manipulated text on the board, and the author used visual displays and graphic tools to enhance the literacy classes.
Thompson & Flecknoe	2003	Management in Education	IWB use had a significant positive impact on both teaching and learning in the classroom. The board helps teach to different learning styles including, kinesthetic, audio, and visual learners. IWBs promote active learning.

APPENDIX B – Table 4 (Cont'd.)

Author(s)	Year	Journal	Learning
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	Many students feel that the IWB helped to initiate and facilitate learning. IWB use also assisted their understanding. Students also felt that the IWB appealed to their visual, auditory and verbal-social learning styles. Students mentioned the value of IWBs in teaching mathematics, English, and science.
Weimer	2001	SmarterKids.org research study	Motivation is an underlying factor in learning and achievement. There is some evidence of a relationship between student motivation and student performance. IWBs allow teaching to a wide range of learning styles.
Wood & Ashfield	2008	British Journal of Educational Technology	If the IWB is used as the focus and hub of interaction, it is possible that learning opportunities may be supported and enhanced in a meaningful way.

APPENDIX B
Table 5 – Pedagogy

Author(s)	Year	Journal	Pedagogy
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	IWB supports whole class teaching concept. When not used interactively, IWBs can reinforce teacher-centered styles of delivery. Rather than transforming pedagogy, IWBs can be easily assimilated into existing pedagogy. IWBs are least effective and have limited impact when teachers do not realize that interactivity requires a new approach to pedagogy. Many teachers are likely to use the IWB as an extension of a regular whiteboard. Helped to break down the barriers between students and normal teacher space. Teachers are the critical agents in mediating the software.
Glover, Miller, Averis, & Door	2005a	Management in Education	At the *interactive stage,* there is a linking of technology and pedagogy. At the *enhanced interactivity stage,* there is an integration of technology, pedagogy, and learning styles.
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	*Missioners* are teachers who not only understand the technology, but also have the ability to see how it can be used to their advantage, and frequently develop software to meet learning situations and foster pedagogic change. *Tentatives*, lack technological skill, but through one-to-one coaching can develop confidence and move ahead. *Luddites* see the technology as a threat. Need to move from didactic to the interactive, and from the use of the IWB as an adjunct to use as an integrated element into lesson planning and the classroom. As teachers become more fluent, the IWB becomes the focus of changed approaches to pedagogy. Unless the IWB is only used as a traditional presentation device, teaching practice must change.

APPENDIX B – Table 5 (Cont'd.)

Author(s)	Year	Journal	Pedagogy
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	Early research focused on benefits of the technology rather than on how pedagogy may need to be changed. Without this, IWBs can be seen as a passing presentational aid or motivational spur. The starting point for changed pedagogy is teacher awareness and implementation of interactivity. *Enhanced interactivity* can be obtained with the following changes to pedagogy: planning for cognitive development, clear visual representation of concepts, activities that encourage an active thinking approach, progression, illustration, sequencing, immediate feedback, and recall to strengthen learning.
Hall & Higgins	2005	Journal of Computer Assisted Learning	Students are keenly aware of any shortcomings in their teachers in relation to pedagogical uses of the IWB. In order to realize the potential of the IWB, teachers need to be confident in their use. Students would like to have more access to using the board themselves. This leads to more exploratory learning. As teachers begin to use the IWB, their traditional teaching practices give way to new more flexible ones. There is clearly a power, status and control issue in an IWB classroom. The teacher role needs to change to more of a facilitator, and allow for more exploration. This can be difficult as teachers are under pressure to get through the curriculum and raise standards and attainment. This is more of an issue in Great Britain than in the US where teachers are less open to the notion of more pupil participation.

Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	IWBs are well adapted to whole-class teaching. Effective pedagogical interactivity requires structured lesson planning, pace in activities, and a cognitive review. “Good teaching remains good teaching with or without the technology; the technology might enhance the pedagogy only if the teachers and pupils engaged in 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” (p. 217). As teachers become more fluent, they recognize the link to pedagogical change, and become a catalyst for further change.
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	Pedagogy is defined as “being the interactive process that goes on between teachers and children, in this case in planned learning” (p. 293). Teachers need to adjust their style to be more inclusive and cooperative in supporting learning. Teacher and student must work together rather than adopting the traditional formal roles of teacher and learner. This is more common with younger children, and becomes less frequent when teaching older children. If teaching with IWBs is to work well, the IWB has to be used as a mediating artifact. Teachers must also allow students to interact with the IWB. Lesson plans must be structured, with associated resources and can now be stored and accessible anytime. Three pedagogic stages: *Stage 1* – teachers fitting new technologies into existing pedagogy, *Stage 2* – teachers engaging in collaborative exploration, *Stage 3* – teachers using the technology skillfully and intuitively thus extending and expanding existing pedagogy. High levels of technical expertise are not necessary to transform pedagogy.
Martin	2007	Literacy	Whole-class teaching and having students interact with the board slowed down the pace of lessons. Confident use is essential for success.

APPENDIX B – Table 5 (Cont'd.)

Author(s)	Year	Journal	Pedagogy
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	There is a need for pedagogic change from the didactic to the interactive, and from using media as a visual support, to the integration of media into lesson planning and IWB use. As teachers become more aware of the range of ways of working with IWBs, they gain confidence and lessons have greater impact. Early evidence suggests that IWBs are a useful "prop" for teachers looking to expand their teaching to differing learning styles, but real gains may only be realized when good teachers are provided with the necessary time, resources, and training.
Schmid	2006	Computer Assisted Language Learning	There is a point of conflict between teacher and student use of the technology. Some teachers prefer a more traditional classroom, and students prefer lessons where they move between using the IWB and their desks. Some students wanted to use the board to hide and deal with their difficulties individually, while other students wanted to create a sense of community, and work out difficulties with the help of the group. If IWBs are to transform pedagogy, dialogue between students and teachers is essential.
Schroeder	2007	Communications in Information Literacy	

Schuck & Kearney	2007	Study done at The University of Technology Sydney	Research suggests that IWBs are mainly being used to reinforce current teaching approaches such as the teacher as the central authoritative expert. The fact that IWBs are not a disruptive technology is both a weakness and a strength. The impact of IWBs was most positive in terms of the increased preparation that teachers were putting into their lessons. Teachers also said that they were spending more time thinking about their students' individual learning styles as a result of using the IWB. Teachers play a critical role in ensuring effective use of IWBs as pedagogical tools at all stages. The type of pedagogical approach that teachers take with IWBs largely depends of attitude, and a willingness to embed the technology into their teaching style. This is dependent on contextual factors (listed in Table 1). Teachers need to be at the *enhanced interactive* stage have the time for planning and preparation. There was strong emphasis on the increased pace of lessons resulting from the ability to quickly access materials on the IWB. Teachers believe that the IWB embraces children's digital culture. Teacher confidence with the IWB is important. Small group work was infrequently used in IWB instruction. In general there was little use of the full potential of IWBs.
Shenton & Pagett	2007	Literacy	IWBs can potentially offer a multimodal approach to teaching literacy. Teachers generally see the IWB as a new item in their teaching toolkit rather than something that might change their teaching methodology. The potential for IWBs is more obvious in subjects other than literacy.

APPENDIX B – Table 5 (Cont'd.)

Author(s)	Year	Journal	Pedagogy
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	Teachers report on the IWB's efficiency, flexibility, versatility, and the ability to access multimedia content while being able to manage the class more easily. In cases where teachers didn't have the proper IWB skills, the technology was poorly used. Students are keenly aware of this deficiency. Teachers must continue to practice the skills they have acquired from previous training classes. It is suggested that a laptop and data projector are a worthwhile investment and the advantage of improved classroom visibility to computer-based content was the main factor, not the board. Knowledge of IWB skills does not mean that they are being applied. Perhaps the best way to incorporate IWBs into teaching and learning is to first roll out a computer with a data projector. Allow teachers to become comfortable with this technology, then after a year or so, (after teachers have proven that they could and wanted to incorporate the technology into their teaching) give them an IWB. Technologies should not be imposed as they can have disruptive effects. Teachers need time to engage with the technology and find ways that it can be used to suit their pedagogic strategies.
Smith, Hardman, & Higgins	2006	British Educational Research Journal	Research suggests that *dialogic teaching* strategies are often not implemented, as more traditional patterns of whole class interaction are used. Study found that IWB lessons contained more whole class teaching and less group work. IWB lessons had significantly more open questions, answers from students, and evaluation. This increased the pace of the lessons. No gender differences were found on frequency of answering questions, but overall this number was higher among IWB lessons. This effect did not last the second year.

			Study finds support for some IWB claims, but no fundamental change in underlying pedagogy. IWBs do not provide a technological fix in order to bring about a fundamental change in the underlying pedagogy of whole class teaching.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	Teaching themes include flexibility, versatility, multimedia/multimodal presentation, efficiency, supporting planning, and interactivity and participation in lessons. IWBs facilitate whole class discussions which lead to sharing of ideas and generation of theories. Facing the class while teaching is reported as a major advantage as teachers can spend more time focusing on students. This is also a more comfortable pedagogic stance for teachers. Some literature state that IWB use has far from transformed classroom practice. Many teachers have uncritically absorbed IWBs in to their pre-IWB teaching practices.
Solvie	2007	Educational Philosophy and Theory	IWBs facilitate preparation of lessons and navigation to specific components during instruction. The author's initial use of IWBs as a tool to gain and maintain attention transformed over time as a tool for engaging students in the lesson. The author reconsidered his pedagogical practice and transformed his teaching practice.
Thompson & Flecknoe	2003	Management in Education	Study used a ready made application called *Easiteach Maths* which helps teachers deliver math lessons via the IWB.
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	

APPENDIX B – Table 5 (Cont'd.)

Author(s)	Year	Journal	Learning
Weimer	2001	SmarterKids.org research study	
Wood & Ashfield	2008	British Journal of Educational Technology	Research indicates that it is the skill and professional knowledge of the teacher who mediates the interaction between the technology and the students in whole-class lessons. The quality of the teaching in these whole-class lessons determines its success. Research shows, however, that IWB use is not transforming the underlying pedagogy of whole-class teaching, as it remains largely unaffected. Teachers must teach creatively, by including a wide range of media such as video, animations, graphics, and text. This creative teaching must contain relevant content for students to have ownership. The pace of lessons can be maintained using an IWB as teachers can navigate through material quickly.

APPENDIX B
Table 6 – Achievement

Author(s)	Year	Journal	Achievement
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	
Glover, Miller, Averis, & Door	2005a	Management in Education	
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	There is almost no evidence of measured gains in student progress and long-term achievement as a result of changed teaching and learning approaches. This is likely to change with further research.
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	It is still the quality of teaching that ensures progress; the IWB alone does not guarantee it.
Hall & Higgins	2005	Journal of Computer Assisted Learning	
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	IWBs appear to have a negligible effect in student attainment. After a 2 year study, there were no significant differences in test scores between schools using IWBs and schools in the comparison group. London schools in the Secondary Whiteboard Expansion project, where teachers used the boards in various ways, reported no impact on pupil performance in the first year in which departments were fully conversant with the technology.

APPENDIX B – Table 6 (Cont'd.)

Author(s)	Year	Journal	Achievement
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	Positive gains in literacy, mathematics, and science for children aged 7-11 which was directly related to the length of time that they had been taught with an IWB. These gains were stronger for children of average or above average prior attainment. There was also a lack of impact on the progress of low prior attainment pupils.
Martin	2007	Literacy	Literature states insufficient evidence to identify the actual impact of IWBs on learning in terms of classroom interaction or upon attainment and achievement. Short duration of study did not allow an accurate measurement of achievement.
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	Theoretically, if the IWB is used so that lessons offer variety, challenge and interactivity, student achievement will be enhanced.
Schmid	2006	Computer Assisted Language Learning	
Schroeder	2007	Communications in Information Literacy	

Schuck & Kearney	2007	Study done at The University of Technology Sydney	There is not sufficient evidence in current literature to show links between IWB use and performance attainment. It has been found that there was little or no difference on national test scores in mathematics and science in UK primary schools. Other studies have concluded that there appears to be no evidence linking increased pupil attainment with the use of IWBs.
Shenton & Pagett	2007	Literacy	
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	
Smith, Hardman, & Higgins	2006	British Educational Research Journal	Research suggests that *dialogic teaching* can lead to higher levels of student achievement.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	There does not appear to be any empirical evidence linking IWBs use and attainment.
Solvie	2007	Educational Philosophy and Theory	The author imagined that by increasing students' attention, achievement would increase as well. This was not as successful as hoped.
Thompson & Flecknoe	2003	Management in Education	Study used a ready made application called *Easiteach Maths* which helps teachers deliver math lessons via the IWB. There was a 14.1% improvement in attainment in first term, a 22.1% improvement in the second term, and a 39.4% improvement overall. All children, regardless of prior attainment made similar gains although lower prior achievement students made a higher proportional gain.

APPENDIX B – Table 6 (Cont'd.)

Author(s)	Year	Journal	Achievement
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	
Weimer	2001	SmarterKids.org research study	Motivation is an underlying factor in learning and achievement. There is some evidence of a relationship between student motivation and student performance.
Wood & Ashfield	2008	British Journal of Educational Technology	

APPENDIX C
Table 1 – Directions for Future Research

Author(s)	Year	Journal	Directions for Future Research
Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson	2005	Educational Review	
Glover, Miller, Averis, & Door	2005a	Management in Education	
Glover, Miller, Averis, & Door	2005b	Technology, Pedagogy, and Education	Need to consider both the technology and the pedagogy of interactivity. Need to better research IWB features such as storage and retrieval of data and lesson plans; potential gains from printing and posting to the web of IWB material. Differing perceptions based on gender. Need both generic and subject-specific investigation of learning gains. Need to investigate the link between concepts and cognitive development in an IWB-rich environment. Need to research long-term achievement gains as a result of changed teaching and learning approaches. Need to look into whether the costs of equipment, training, software, maintenance, and support have brought anticipated gains (ROI).
Glover, Miller, Averis, & Door	2007	Learning, Media and Technology	
Hall & Higgins	2005	Journal of Computer Assisted Learning	

APPENDIX C – Table 1 (Cont'd.)

Author(s)	Year	Journal	Directions for Future Research
Higgins, Beauchamp, & Miller	2007	Learning, Media and Technology	Need better studies on IWB use and low-attaining, very young pupils. Need to look into how increased motivation due to IWB use is translated into learning. Need to look into the direction that teachers need to move to ensure that the proven changes that IWBs have on interaction and pedagogy, translate to an increase in learning.
Lewin, Somekh, & Steadman	2008	Education & Information Technologies	
Martin	2007	Literacy	Longitudinal studies are necessary. Need to investigate how IWBs can be used more effectively for teaching writing. Need to look at which strategies are effective in enhancing the progress of all learners.
Mechling, Gast, & Krupa	2007	Journal of Autism & Developmental Disorders	Need to compare IWB technology to more traditional setups such as flash cards for teaching sight word reading. Should also more fully examine interactive and multi-media features of technology for delivering instruction to students with differing abilities.
Miller, Glover, & Averis	2004	Paper presented at Tenth International Congress of Mathematics Education	
Schmid	2006	Computer Assisted Language Learning	

Schroeder	2007	Communications in Information Literacy	Many studies are done in the K-12 sector, and more research needs to be done in college and university settings. The development of an instrument to measure and assess the impact of instructional methods, such as IWB use, is needed. Need studies investigating the cognitive and long-term effects of IWB use in the classroom.
Schuck & Kearney	2007	Study done at The University of Technology Sydney	How does pedagogy with IWBs change over time? How are learning outcomes influenced by IWB use? How do teachers view IWBs in terms of its use as a technological tool or pedagogical tool? Studies are needed to assess key learning outcomes after IWBs have been embedded in classroom practice. Need to evaluate benefits of IWB use across all subject areas. Need long-term longitudinal studies. Need more formal studies, rather than relying on anecdotal evidence. What are implications for student teachers? Nature of motivation needs to be investigated. How can IWBs be used in small group work and peer learning?
Shenton & Pagett	2007	Literacy	The commercialization of pedagogical tools needs to be recognized and researched. Using IWBs in a cross-curricular approach needs to be addressed.
Slay, Siebörger, & Hodgkinson-Williams	2008	Computers & Education	If IWBs are going to be used with traditional didactic teaching methods, should schools simply invest in a computer and a data projector as the interactive nature of the IWB is not used? The added benefit of interactivity needs to be weighed up against the benefits perceived by the school, its administrators, teachers, and students.

APPENDIX C – Table 1 (Cont'd.)

Author(s)	Year	Journal	Directions for Future Research
Smith, Hardman, & Higgins	2006	British Educational Research Journal	Research is needed to collect empirical evidence on the process of teaching and learning using IWBs. A good place to start is to look at the intersection between technical and pedagogic interactivity.
Smith, Higgins, Wall, & Miller	2005	Journal of Computer Assisted Learning	
Solvie	2007	Educational Philosophy and Theory	
Thompson & Flecknoe	2003	Management in Education	
Wall, Higgins, & Smith	2005	British Journal of Educational Technology	The effect of IWBs on motivation in the long-term needs to be addressed.
Weimer	2001	SmarterKids.org research study	
Wood & Ashfield	2008	British Journal of Educational Technology	

REFERENCES

Armstrong, V., Barnes, S., Sutherland, R., Curran, S., Mills, S., & Thompson, I. (2005). Collaborative research methodology for investigating teaching and learning: The use of interactive whiteboard technology. *Educational Review, 57*(4), 457-469.

Glover, D., Miller, D., Averis, D., & Door, V. (2005a). Leadership implications of using interactive whiteboards. *Management in Education, 18*(5), 27-30.

Glover, D., Miller, D., Averis, D., & Door, V. (2005b). The interactive whiteboard: A literature survey. *Technology, Pedagogy & Education, 14*(2), 155-170.

Glover, D., Miller, D., Averis, D., & Door, V. (2007). The evolution of an effective pedagogy for teachers using the interactive whiteboard in mathematics and modern languages: An empirical analysis from the secondary sector. *Learning, Media, & Technology, 32*(1), 5-20.

Hall, I., & Higgins, S. (2005). Primary school students' perceptions of interactive whiteboards. *Journal of Computer Assisted Learning, 21*(2), 102-117.

Higgins, S., Beauchamp, G., & Miller, D. (2007). Reviewing the literature on interactive whiteboards. *Learning, Media, & Technology, 32*(3), 213-225.

Lewin, C., Somekh, B., & Steadman, S. (2008). Embedding interactive whiteboards in teaching and learning: The process of change in pedagogic practice. *Education & Information Technologies, 13*(4), 291-303.

Martin, S. (2007). Interactive whiteboards and talking books: A new approach to teaching children to write? *Literacy, 41*(1), 26-34.

Mechling, L., Gast, D., & Krupa, K. (2007). Impact of SMART Board Technology: An investigation of sight word reading and observational learning. *Journal of Autism & Developmental Disorders, 37*(10), 1869-1882.

Miller, D., Glover, D., & Averis, D. (2004). *Panacea or prop: The role of the interactive whiteboard in improving teaching effectiveness.* Paper presented at the Tenth International Congress of Mathematics Education, Copenhagen, July. Available online at: http://www.icme-organisers.dk/tsg15/Glover_et_al.pdf (accessed February 12, 2009).

Schmid, E. (2006). Investigating the use of interactive whiteboard technology in the English language classroom through the lens of a critical theory of technology. *Computer Assisted Language Learning, 19*(1), 47-62.

Schroeder, R. (2007). Active learning with interactive whiteboards: A literature review and a case study for college freshmen. *Communications in Information Literacy, 1*(2), 64-73.

Schuck, S., & Kearney, M. (2007). Exploring pedagogy with interactive whiteboards: A case study of six schools (Sydney, University of Technology Sydney). Available online at: http://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreport web.pdf (accessed February 12, 2009).

Shenton, A., & Pagett, L. (2007). From 'bored' to screen: The use of the interactive whiteboard for literacy in six primary classrooms in England. *Literacy, 41*(3), 129-136.

Slay, H., Siebörger, I., & Hodgkinson-Williams, C. (2008). Interactive whiteboards: Real beauty or just "lipstick"? *Computers & Education, 51*(3), 1321-1341.

Smith, F., Hardman, F., & Higgins, S. (2006). The impact of interactive whiteboards on teacher–pupil interaction in the National Literacy and Numeracy Strategies. *British Educational Research Journal, 32*(3), 443-457.

Smith, H., Higgins, S., Wall, K., & Miller, J. (2005). Interactive whiteboards: Boon or bandwagon? A critical review of the literature. *Journal of Computer Assisted Learning, 21*(2), 91-101.

Solvie, P. (2007). Leaping out of our skins: Postmodern considerations in use of an electronic whiteboard to foster critical engagement in early literacy lessons. *Educational Philosophy & Theory, 39*(7), 737-754.

Thompson, J., & Flecknoe, M. (2003). Raising attainment with an interactive whiteboard in Key Stage 2. *Management in Education, 17*(3), 29-33.

Wall, K., Higgins, S., & Smith, H. (2005). 'The visual helps me understand the complicated things': Pupil views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology, 36*(5), 851-867.

Weimer, M. J. (2001) The influence of technology such as SMART board interactive whiteboard on student motivation in the classroom. Available online at: http://smarterkids.org/research/paper7.asp (accessed February 12, 2009).

Wood, R., & Ashfield, J. (2008). The use of the interactive whiteboard for creative teaching and learning in literacy and mathematics: A case study. *British Journal of Educational Technology, 39*(1), 84-96.

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