Interactive Whiteboards for Teacher Training: A Literature Review

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In the next five years, more than seven million interactive whiteboards (IWB) will have been installed, the equivalent of one in every five classrooms worldwide (EFY News Network, 2009). With such financial resources invested, educators are experimenting with implementation and IWBs use. While initial research reported increased learner motivation and engagement, more recent evidence suggested that these positive outcomes might not translate into improved learner outcomes.

IWB use has been well documented in elementary classrooms in the United Kingdom, but limited at secondary and university setting. Currently, no research exists on the use of IWBs in professional development among teachers. With IWBs being installed at such a rapid rate in schools, teachers could become another potential audience for the use IWBs in education. This literature review will discuss the needs of teachers as adult learners, outline criteria for successful professional development, describe the background of IWBs, follow its current usage and research trends, highlight its potential, explore emerging issues, analyze pedagogical implications, and identify future areas of research.

Teacher Training

In professional development, typical roles are reversed, as classroom teachers become the students. The profile of these "students" differs markedly from the typical K-12 or university student. Teachers are mature adult learners and professional development must be designed to accommodate their needs.

Teachers as Adult Learners

Knowles indicated that as learners mature, several transitions occur: they become more self-directed learners, their life experiences become valuable resources, their readiness to learn is

more dependent upon their social roles or tasks, they focus on solving immediate problems, and their motivation is internalized (as cited in Yoshimoto, Inenaga, & Yamada, 2007). For trainers, this means that mature learners become clients rather than just students, and the emphasis is on relevant skills and knowledge (Yoshimoto, Inenaga, & Yamada, 2007).

After a review of various adult learning theories including Age and Stage Theory, Cognitive Development Theory, and Functional Theory, Trotter summarized that mature adult learners draw upon their wealth of prior experience, need flexibility to develop their own educational goals based on interest and classroom needs, and require education that promotes individual development through reflection and inquiry (as cited in Williams, 2008). Any successful professional development program should attempt to accommodate these characteristics.

Professional Development Programs

Mezirow suggested that there are three types of adult learning: instrumental (focuses on a specific skill), dialogic (communal learning to search for understanding), and self-reflective (reflection leads to understanding and change in performance) (as cited in Slepkov, 2008). Most traditional professional development opportunities for teachers fall into the instrumental category, which usually involves the direct transmission of knowledge or skill. This mode of training replicates the traditional model of the standard K-12 classroom (Slepkov, 2008). Increasingly, however, research points to a growing awareness of the need for more continuous self-reflective professional learning in order for true pedagogical growth and change to occur (Slepkov, 2008).

Unfortunately, technology training (e.g. learning how to use a new software), a typical example of instrumental learning, usually falls short of its intended goals. Plair (2008)

categorized technology training based on skill level into: awareness, how to, seminars or workshops, and ongoing support. Most of the current technology training for teachers falls into either the "awareness" or "how to" categories that involve short sessions for introduction of new technology or practice. Because this type of training is typically provided on a large scale to accommodate all teachers, there is usually little emphasis on content or grade level. This often results in teachers returning to the classroom too confused to get started with the new technology (Plair, 2008). These short training sessions that rely on teachers working in isolation tend to yield few positive results (Slepkov, 2008). In order for teachers to successfully implement technology, ongoing support is critical.

Ongoing support and continuous training may not always be feasible, however, due to time or budgetary constraints. Teachers identified time is the most common barrier to implementing new technology (Plair, 2008). Administrators also face the challenge of arranging professional development to accommodate class schedules (Slepkov, 2008). The question remains as to what can be done to make the limited training opportunities that are available as productive and effective as possible.

Ward recommends that professional development for adults meet the following five criteria: relate the content to the needs of the participants, cater to participants' learning styles, foster learner self-esteem, provide a stimulating and supportive environment, and establish clear expectations (as cited in Williams, 2008). While not a stand-alone solution, interactive whiteboard technologies can be used to address many of these criteria. The multimodal nature of IWBs appeal to a range of learning styles, and with the use of an integrated learner response system can provide immediate anonymous feedback that fosters learner self-esteem in an interactive, engaging, and stimulating learning environment.

Background of Interactive Whiteboards

Definition

There are two very different types of technology that can both be referred to as "interactive whiteboards". The first type is a virtual electronic whiteboard used in conferencing and data-sharing systems like Microsoft NetMeeting or Elluminate to allow viewers to follow a presenter's graphic input (TechLearn, 2003). The second type of interactive whiteboard involves the combination of a touch-sensitive whiteboard, computer with accompanying software, and digital projector (Clyde, 2004; Hall & Higgins, 2005; TechLearn, 2003). Images originating from the computer are projected on to the whiteboard, which can be controlled from the front of the room by touching the screen or using a specialized stylus (Clyde, 2004; Hall & Higgins, 2005). For the purpose of this literature review, the terms "interactive whiteboard" will be used to represent this second type of technology, also called "electronic whiteboard", "digital whiteboard", "smart whiteboard" or "interactive white board" (Clyde, 2004). The key players in the IWB market are Smart Technologies and Promethean, though many other smaller companies like Mimio, Numonics, Hitachi, Polyvision, and Panasonic also produce IWBs (Linh, 2009; Starkman, 2007). According to Hall and Higgins (2005), IWBs represent "a conglomeration of all previous educational technologies," replacing traditional chalk or whiteboards, televisions, videos, overhead projectors, and personal computers (p. 106).

Features

Due to this integration of previous technologies, interactive whiteboards have become characterized by their multimedia capabilities including: visual displays, audio, and touch sensitivity (Hall & Higgins, 2005). Like a traditional digital projector, an IWB can display an enlarged computer image from the front of the room, allowing visibility for all participants,

rather than having small groups cluster around personal computers in the classroom (Gatlin, 2004).

The touch-sensitive screens enable physical manipulation of images, with the implication that they can be used with a wider audience including very young children and those with special needs (Clyde, 2004). The touch-sensitivity allows instructors to annotate using electronic notes (Gatlin, 2004). Software designed for IWBs, however, also usually permit instructors to record live classroom activity. These recordings can be posted to websites for later review or in case of absentia (Fletcher, 2006). The ability to save lessons also helps instructors keep separate annotations and pacing for each session (Nolan, 2009).

Many IWBs also have optional input devices that can be used for formative or summative assessments. These "voting devices" can release the instructor from the front of the room and enable greater learner involvement, meanwhile reducing the threat of exposure and maintaining privacy (Hennessy, Deaney, Ruthven, & Winterbottom, 2007).

Hall and Higgins (2005) provided some suggestions regarding the potential use of IWBs in the classroom including: display of web-based resources or video clips to explain a concept, modeling software use, presentation of student work, digital lesson and flip chart creation, text manipulation, handwriting practice, saving of notes, and editing (Hall & Higgins, 2005). While many of these applications are not unique to IWBs and can be done simply using a computer and projector, the annotation and physical manipulation features inherent in IWBs are an often remarked upon use by instructors (Clyde, 2004; Gatlin, 2004; Jewitt, Moss, & Cardini, 2007; Starkman, 2007).

Trends in Interactive Whiteboard Use and Research

According to Higgins, Beauchamp, and Miller (2007), "the use of IWB may be the most

significant change in the classroom learning environment in the past decade," (p. 221). It appears IWB technology couldn't have come at a better time. According to the American Academy of Pediatrics, children in the United States watch television an average of four hours daily (as cited in Villano, 2006). Furthermore, the National Academy of Sciences indicated that 26% of teenagers spend an additional one to two hours online per day (as cited in Villano, 2006). These statistics, though alarming, indicate that learners increasingly operate in a highly visual environment, preferring to have information on demand; luckily, the latest classroom display technologies are ready to meet these needs (Villano, 2006).

Analysis by Country

Despite the potential of IWBs and the surge in its use, classroom penetration still remains low in the United States, with over two-thirds of districts reporting that fewer than ten percent of their classrooms are equipped with whiteboards ("Extracurricular", 2007). While there is concern that other countries including Mexico, China, and the United Kingdom are surpassing America in adoption of IWB technology (Starkman, 2006), the EFY News Network indicated that the US is still currently the largest and fastest-growing IWB market (2009). Recently, Marzano and Haystead (2009) conducted the first large-scale study on IWBs in the United States. This quasi-experimental evaluation study sought to determine the effect of Promethean's ActivClassroom system on student achievement. The findings indicate that large percentile gains in student achievement were found when the teacher was experienced, had used the IWB system for an extended period of time, used the system significantly in the classroom but not more than 80% of the time, and has high self-confidence in regards to the use of the system (Marzano & Haystead, 2009).

The high utilization of whiteboards in the United Kingdom, especially at the primary

level, can be attributed to financial support from the national government. The Department of Education and Skills provided £10 million to the Primary Schools Whiteboard Expansion project for the installation of whiteboards in 2003 and 2004 (Haldane, 2007). This project represents part of a larger effort by the government to have teachers imbed Information and Communications Technologies (ICT) into their practice in order to improve teaching and learning (Gray, Pilkington, Hagger-Vaughan, & Tomkins, 2007). Similar to our efforts in the United States to promote 21st century skills, ICT represents a set of skills desired by employers that are needed in the future world economy. As a result, ICT has become a key component in the United Kingdom's education strategy to raise student achievement, and the expectation is that all teachers will be knowledgeable in the use of ICT to improve academic performance (Gray et al., 2007). The byproduct of these efforts is the number of government-funded studies analyzing the impact of IWB use in schools, especially at the primary level.

Though other countries no doubt are adopting IWB technology for education, the accessible research remains limited due to language constraints. While it remains difficult to access and understand research that is not produced in English, there are a small number of studies written in English that focus on IWB use elsewhere. One recent study by Somyürek, Atasoy, and Özdemir (2009) focused on IWB implementation in the Turkish education system. Hall and Higgins (2005) cited an Australian study conducted by Lee and Boyle in 2003 that focused on how IWB use transformed teachers' traditional practices. Starkman (2006) mentioned use of IWB in Canadian provinces, but no formal study was conducted.

Due to the increasing body of research that is emerging on the implementation of IWBs in the classrooms, analysis has been necessary to summarize and identify general trends. Smith, Higgins, Wall, and Miller (2005) conducted the first literature review since the mass

implementation of IWBs in UK schools in 2003-2004. After a number of studies were subsequently published based upon this initial implementation, Higgins et al. (2007) followed up with a second literature review to incorporate the new findings. Due to their comprehensive nature, both articles are frequently referenced in the writings of subsequent studies concerning IWBs.

Analysis by Content Area

In terms of subject matter, IWB use has been documented and studied in a variety of content areas. Research in the area of literacy supported the teaching of site words, documented increased correct reading and matching of target words, and showed evidence of rapid increase in student reading levels (Mechling, Gast, & Krupa, 2007; Starkman, 2007). In terms of writing, however, Martin (2007) found no significant improvement in writing ability after students were taught using IWB integrated lessons. Additional studies have also been performed in literacy classrooms by Shenton and Pagett (2007), Smith, Hardman, & Higgins (2007), and Wood and Ashfield (2008), though their studies varied in areas of concentration.

Many of these same authors also observed mathematics classrooms. Little of this research, however, focused on the effectiveness of IWB on this content area, but rather on the implementation and impact on teachers and students in a broader sense. Thompson and Flecknoe (2003), however, conducted a small-scale study prior to the nation-wide IWB initiative and found that IWB use for mathematics in the upper-primary grades resulted in 39% improvement in student achievement over the course of a year. The results indicate that all students had surpassed the expected progress for that year, with the greatest gains being made among those with low prior achievement (Thompson & Flecknoe, 2003). It is yet to be seen whether these results can be confirmed with additional research.

Because of the national standards for literacy and numeracy in the United Kingdom, like those set for language arts and math in the United States by the *No Child Left Behind Act*, there is limited research concerning IWB use in other content areas. Nevertheless, studies have been conducted in the areas of foreign language (Glover, Miller, Averis, & Door, 2007; Gray et al., 2007; Schmid, 2006; Toczu, 2008), science (Hennessy et al., 2007), and music (Baker, 2007; Nolan, 2009). Interestingly, however, this does not coincide with the areas of greatest use since districts in the United States reported the highest use of IWBs in elementary language arts and social studies classes ("Extracurricular", 2007).

Analysis by Education Level

Due to the financial support provided as part of the Primary Schools Whiteboard Expansion project in the United Kingdom, a number of studies were funded to analyze the implementation and use of IWBs in primary classrooms and determine whether the money was well-spent. This collective research represents a disproportionate amount of the existing body of knowledge concerning IWB use in educational settings. Nevertheless, a smaller number of articles have been written regarding IWB use at both the secondary (Jewitt et al., 2007; Hennessy et al., 2007; Miller & Glover, 2007; Starkman, 2006) and university levels (Schimd, 2006; Toczu, 2008). Market penetration in higher education is lower and perhaps may be due to large class sizes and the limited opportunities for interaction within such large group settings (TechLearn, 2003). Beyond use in the formal education environment, research is significantly lacking on IWB use in continued employee professional development and training.

The Promise of Interactive Whiteboards

When used successfully, IWBs can be a better investment than one-to-one technologies (O' Hanlon, 2007). IWBs are popular among administrators since the buy-in from teachers is

relatively strong due to their ability to use existing resources or integrate online textbooks seamlessly (O' Hanlon, 2007). Starkman (2006) also provided anecdotal support by including stories from administrators who have witnessed improved grades and reductions in student behavioral issues like suspensions.

Benefits to Learners

The existing research is consistent in the positive feedback received from a majority of students regarding IWB use in the classroom for various reasons (Wall, Higgins, & Smith, 2005). As a combination of existing technologies, IWBs provide a heterogeneous toolkit enabling multiple modes of representation that can be accessed at the teacher's discretion to best suit student needs (Gillen, Littleton, Twiner, Staarman, & Mercer, 2008; Smith et al., 2005).

When instructors are able to incorporate multiple modes of learning, more participants are able to access the content knowledge. Many teachers have remarked on the ability of color graphics and movement to appeal to, motivate, and improve concentration for visual learners (Liles, 2005; Thompson & Flecknoe, 2003; Wall et al., 2005). Audio learners have the benefit of classroom discussions, sound and music (Nolan, 2009; Thompson & Flecknoe, 2003). Kinesthetic learners have the ability to come up to board to write and physically manipulate objects by dragging them (Nolan, 2009; Thompson & Flecknoe, 2003). Though students seem to enjoy coming to the board and touching the screen, Smith et al. (2005) questioned whether this physical interaction actually enhanced learning, or merely motivated students since the physical interaction was not unique to the content.

IWBs are especially useful for accommodating learners with mental or physical challenges (TechLearn, 2003). Mechling et al. (2007) conducted a small-scale study that showed that use of IWBs led to improved reading and target word matching among autistic children due

to increased visibility and attention to the task. Teachers have many options for accommodating to visually or hearing impaired students. They can increase font size or volume and can allow students to control the board through physical manipulation or a keyboard (Nolan, 2009). For students and teachers who are blind, the IWB has allowed them to make reading and writing more accessible (Starkman, 2007). Deaf students can find relief from concentrating on their instructor's signing hands and can focus on material that has been graphically represented for them (Liles, 2005). Furthermore, when sign language is required, teachers are able to remain at the front of the room and control the board rather than needing to return to their computer (Mackall, 2004). Even students with physical impairments that restrict movement can participate using the IWB. Starkman (2007) documented use of IWB technologies by patients with spinal cord injuries and students in wheelchairs who can use an ActivWand, manufactured by Promethean, to reach the IWB allowing physical manipulation of the objects on the screen.

Students have consistently reported that IWBs make learning more fun and exciting ("Extracurricular", 2007; Gatlin, 2004; Hall & Higgins, 2005; Mackall, 2004). Students attribute this increased attention and engagement to the use of multimedia (Hall & Higgins, 2005). However, Hall and Higgins (2005) caution that students occasionally seemed too preoccupied with educational games and that a balance must be struck between meaningful uses of such games and those purely played for gratification. Hodge and Anderson (2007) also caution that though IWB can garner undivided attention from students, it may leave them less able to moderate their own attention, which is an increasingly required skill. Teachers correlate this increased motivation and greater student attentiveness to involvement in class (Gatlin, 2004; Thompson & Flecknoe 2003; Shenton & Pagett, 2007).

Using the IWB, students are able to work collaboratively in a whole-class or small-group

environment to accomplish a shared task (TechLearn, 2003). Students are also able to easily share information and resources with one another (Mackall, 2004). Many teachers indicate that they had previously attempted to incorporate more student-focused learning and group work, but that IWBs allowed them to enhance their teaching towards these ends (Glover et al., 2007). Perhaps this increased participation in class can partly be attributed to developing student confidence. Students developed skills through collaborative work and the need to communicate ideas (Villano, 2006), became more confident in trying new areas of learning (Thompson & Flecknoe, 2003), and even helped teach classes and train teachers in the technology (Fletcher, 2006; Starkman, 2006). The increased number of student presentations may be a short-term benefit, however, as these patterns did not hold true past the first year of observation (Smith, Hardman, & Higgins, 2006).

Benefits to Educators

Though the literature remains inconclusive in terms of student learning gains, the picture becomes much clearer with regards to the benefits for teachers (Kelley, Underwood, Potter, Hunter, & Beveridge, 2007). The similarity of IWBs to conventional whiteboards means that even reluctant teachers can easily adapt to this technology to present information (TechLearn, 2003), since they fit into the spatial and pedagogical status quo with the teacher at the board in front of the room (Jewitt et al., 2007). Through use of IWBs, teachers have found that they are able to more quickly prepare lessons in advance using a greater range of resources that better meet students' needs, execute those lessons more efficiently during class, and better gauge and adapt to student feedback.

Teachers can more easily and quickly create original resources that can be amended or annotated in real time as needed (Hodge & Anderson, 2007; TechLearn, 2003). For example,

teachers can easily prepare a more dynamic presentation including internet resources, software applications like spreadsheets or word processors, and annotated notes (Jewitt et al., 2007 ; TechLearn, 2003). As Gillen et al. (2008) noted, however, "it is not that access to these modes was previously impossible for teachers, but rather that this technology makes it so easy and convenient for the teachers to deploy them," (p. 357). Teachers who used the IWBs realized that greater precision and thought in lesson planning were required than in traditional teaching methods, but encouraged them to design activities that better involved all students, capitalizing on multiple modes of learning to ensure concept progression (Glover et al., 2007; Hodge & Anderson, 2007).

When teachers are able to teach more efficiently, they are able to maximize learning time for their students. These time-saving measures include not having to write notes on the board (Gatlin, 2004), being able to direct student attention to certain sections of the board and keep them focused (Kelley et al., 2007), and ease of transition between screens, links, and applications (Jewitt et al., 2007; Thompson & Flecknoe, 2003). The end result is that of a faster, smoother flowing presentation compared to previous technology (Gillen, Staarman, Little, & Mercer, 2007). These shortcuts may result in teachers freeing up class time that can be used to address individual needs (Glover et al., 2007). Teachers need to be aware, however, that having students participate in manipulating items at the board during whole-class teaching can also slow the pace of the lesson and instill boredom (Smith et al., 2005).

Teachers also remarked on the increased crowd control capability afforded by use of the IWBs, and that this control was gained more subtly and with less open conflict (Gray et al., 2007). Some of this classroom control may be attributed to teachers' abilities to better monitor student progress and the ability to control the IWB from the front of the classroom (Glover et al.,

2007). The improved planning and pacing of the class also left little time for behavioral issues to emerge and resulted in students being more on-task for a greater percentage of the time (Glover et al., 2007).

IWBs can be used with a learner response system (LRS) to gauge student progress and mastery of information, and provide feedback to the instructor instantaneously (TechLearn, 2003). According to LaRose (2009), the use of a LRS "fosters interaction throughout the presentation and helps to keep the audience actively engaged" (p. 58). The accompanying software usually allows teachers to display the results of these lesson checks or assessments either publicly, in summarized form, or privately, identifying specific students scores. Teachers should be aware that students may lose confidence and become reluctant to using the input devices if they are unable to keep these classroom interactions private (Hennessy et al., 2007). By using the LRS anonymously, the instructor can provide a comfortable medium for all students to express their views, meanwhile accommodating students who typically shun the spotlight (LaRose, 2009). This feedback allows the instructor to gauge and respond to the needs of learners in real time, rather than relying on lagging indicators like posttest scores and evaluations (LaRose, 2009).

Emerging Issues

Glover, Miller, Averis, & Door (2005) indicated, "there is much more to the effective use of the technology than simply ensuring that teachers have access to the equipment," (p. 27). Many of the issues that have emerged as a result of IWB implementation are associated with either the technology itself or its use within the classroom.

Resource Management

Inability to see the board is a frequently commented upon problem by students. Students

and instructors manipulating the images on the board can obscure the image on front-projection IWBs (Smith et al., 2005; TechLearn, 2003). Sunlight, dust, shadows, or the inappropriate use of fonts and colors may further impair visibility (Hall & Higgins, 2005; Smith et al., 2005). The height of the board is another consideration to take into account. If placed too high, it may be difficult for students or instructors to reach, and if placed to too low, not all of the screen may be visible to students especially those sitting further back (Smith et al., 2005; TechLearn, 2003).

If IWBs are not permanently mounted in a classroom or shared among teachers, other problems may arise. They can become difficult to secure and may require frequent recalibration, which can disrupt lessons (Clyde, 2004; Smith et al., 2005; TechLearn, 2003). Considerations should be made so that shared IWB classrooms may be accessible to teachers (Somyürek et al., 2009). Furthermore, teachers prefer to use their own classrooms and reported more positive feedback about the experience when IWBs were permanently mounted (Smith et al., 2005). This research suggests that when cost is not an issue, the ideal scenario for installation is to permanently mount the IWBs in each teacher's classroom.

In addition to the need for proper equipment, teachers stress the importance of digital education resources since they frequently constitute content and curriculum objectives for many teachers (Wall et al., 2005). Teachers indicated that available education material from even the largest vendors was effectively inadequate or not tailored to their needs (Nolan, 2009; Somyürek et al., 2009). When the available digital resources are limited, repetitive use may lead to disinterest and underutilization (Somyürek et al., 2009). The greater the available software, the greater are the benefits, and the higher the return on investment (Thompson & Flecknoe, 2003). On the other hand, with the increasing availability of resources, teachers must be careful not to simply become "software operator[s]; acting as a human conduit between class and software"

(Wood & Ashfield, 2008, p. 95). As with other aspects of teaching, teachers must continue to identify the best tools and resources for a specific educational purpose, rather than use the materials "right out of the box".

Consistent and available technical support during planning and instruction is critical for a successful IWB implementation (Hall & Higgins, 2005; Smith et al., 2005). From the perspective of the students, technical problems cause disruption, delay, frustration, and a lack in confidence in the new technology, resulting in underutilization (Hall & Higgins, 2005). Such technical problems may include broken or damaged equipment, power outages, and computer problems including malfunction or slow start-up (Somyürek et al., 2009). Wall et al. (2005) emphasized that it is equally important for manufacturers to be cognizant of the impact that technical problems may have on teaching and learning in the classroom. Glover et al. (2005) recommended that all schools develop a resource management program to include the introduction, maintenance, and insurance of IWB equipment to minimize disruptions due to technical problems.

IWB Training

The predominant concern of schools when implementing IWBs must be to select appropriate training opportunities and to do so early in the process (Glover et al., 2005; Miller & Glover, 2007). After all, "interactive whiteboards are only as effective as the instructors using them. To use the boards to their full effect, teachers must receive proper training" (O' Hanlon, 2007). Traditional training for many teachers usually begins and ends with an induction from the vendor, as was true in the study conducted by Shenton and Pagett (2007). Though initial training provided by vendors is typically highly motivating, enthusiasm for the use of IWBs wanes without continued support (Smith et al., 2005).

Instead, professional development should entail both technical and pedagogical training (Miller & Glover, 2007) over multiple and continued training sessions so that teachers can maintain and develop their skills (Hall & Higgins, 2005). Additionally, Miller and Glover (2007) encouraged the use of mentoring relationships in schools, since coaching seemed to be more effective in promoting technological and operational confidence over traditional top-down training approaches. Many authors also indicated a need for the development of a professional learning community that provided opportunity for teachers to share their experiences, teaching strategies, and resource materials as they attempt to adjust from traditional teaching patterns to more responsive teaching (Kennewell & Beauchamp, 2007; Miller & Glover, 2007; Smith et al., 2006).

Administration can provide additional support by allotting and protecting teacher planning time for the development of new educational resources, collaboration with teachers in the professional learning community, and reflection on their teaching practice (Glover et al., 2007; Gray et al., 2007; Jewitt et al., 2007). Most teachers new to IWBs spend an inordinate amount of time developing new teaching materials and learning how best to integrate them into their teaching practice (Gray et al., 2007; Hodge & Anderson, 2007). To alleviate this problem, it has been suggested that teachers be provided with downloadable ready-made texts, but the process of material creation provides teachers with the greatest control in the preparation and use of electronic resources and teachers need to be supported as they exercise this autonomy (Jewitt et al., 2007; Wood & Ashfield, 2008).

Impact on Teaching and Learning

There is growing concern that without proper training, the way many teachers are using the IWBs may be perpetuating the traditional teaching structure with the teacher in the front of

the room and all students remaining seated with their attention directed at the board. Teachers new to IWBs may find themselves in the trap of reverting to whole-class teaching, using class-long PowerPoint presentations, and acting the role of the "sage on the stage" doling out information (Fletcher, 2006; Hall & Higgins, 2005; Hodge & Anderson, 2007; Kennewell et al., 2008; O' Hanlon, 2007; TechLearn, 2003). Perhaps this is due to the fact that aspects of direct teaching, like explaining, modeling, and demonstrating, were facilitated with the IWB (Wood & Ashfield, 2008).

Thompson and Flecknoe (2003) called for peer interactivity to be the goal, since doing so would motivate and empower students to take charge or their own learning. Unfortunately, many teachers consider greater interactivity to be a property of the board, rather than with peer interactivity or teacher-student interaction (Shenton & Pagett, 2007). While there have been documented cases in which IWBs have resulted in positive changes to traditional teaching practices (Glover et al., 2007; Gray et al., 2007; Hall & Higgins, 2005), the findings from Smith et al. (2006) indicated that classes with IWBs contained more whole-class teaching, were faster-paced, and had less group work than non-IWB classes. While some claims regarding IWB use and instruction were substantiated, several authors did not find a fundamental change in teachers' basic pedagogy toward more self-directed student learning and empowerment (Smith et al., 2006; Kennewell & Beauchamp, 2007).

Student feedback indicates that they want more opportunities to interact with the board, but are prevented from doing so by the teacher (Hall & Higgins, 2005). Opportunities for student use of the board were reported to be lacking due to external time pressures and the need to cover the curriculum (Hennessy et al., 2007). This was true despite the teachers acknowledging that overuse of teacher demonstrations and presentations to be unwise (Hennessy

et al., 2007). Nevertheless, given sufficient time and opportunity to reflect, many teachers are proving that whiteboards can be used effectively to encourage a student-centered learning environment (Fletcher, 2006; O' Hanlon, 2007).

Though a substantial body of anecdotal evidence exists regarding the impact of IWB on student motivation, empirical evidence is conflicting as to whether this increased engagement is translating into academic achievement. Some research indicates that students are able to absorb information more easily using IWB technology resulting in improved academic performance (O' Hanlon, 2007; Thompson & Flecknoe, 2003; Tozcu, 2008). Additional literature remains inconclusive regarding student learning gains attributable to IWB use (Kelley et al., 2007; Kennewell & Beauchamp, 2007; Smith et al., 2005). More research needs to be conducted to determine if current IWB use is effective and what strategies and policies should be adopted in order to maximize the potential of IWBs in the classroom.

Pedagogical Implications

Considerations for Administrators

The teacher is the most important factor in student achievement (Gatlin, 2004). Without imaginative and innovate teachers, any new technology, no matter how multimodal and interactive, will not be able to instill fundamental changes in classroom instruction (Glover et al., 2007; Smith et al., 2006; Thompson & Flecknoe, 2003). Research from Wood and Ashfield (2008) indicated that the skill of the instructor in fusing technology and pedagogy to mediate interaction and develop student creativity and thinking is critical to enhancing the teaching and learning processes. For this reason, pedagogical training and changes to pedagogical understanding are critical in maximizing use of IWBs (Smith et al., 2005; Smith et al., 2006).

Glover et al. (2007) suggested that after initial training, teachers progress through three

stages of pedagogical development: supported didactic, interactive, and enhanced interactive. This process usually occurs through a combination of personal experimentation, trial and error, and the gradual building of an arsenal of useful materials (Gray et al., 2007). Progress from didactic to enhanced interactive pedagogy can be supported through administrative support, pedagogic training and understanding, availability of equipment, and the development of both technical and pedagogic skills (Glover et al., 2005).

Considerations for Educators

In addition to training the teachers, the students must be prepared as well. One consideration for teachers is that though an increasing number of students may be considered digital natives, all students need proper training on the equipment in order to maximize their confidence and use of the IWB. Teachers, as well as students, need time to overcome the learning curve to adapt to the new technology and understand how it can possibly change their classroom interaction and learning experience (Glover et al., 2005; Schmid, 2006). Students must be taught the manipulative skills required in order to be technologically competent and operate the IWB with confidence (Glover et al., 2005). Only with technological competency will students be self-directed learners and be more likely to actively participate (Hall & Higgins, 2005; Hennessy et al., 2007).

While IWB technology has resulted in improved pacing and teaching efficiency, teachers must be aware of the implications and design instruction and resource materials accordingly. Jewitt et al. (2007) suggested that these considerations should be taken into account during the development of educational resources like flipcharts or presentations, since the slide format forces chunking of information into smaller, sequential parts, resulting in the possible loss of continuity required of more complex and extended topics that formerly had the advantage of

spreading across multiple boards on the wall. Furthermore, there remains significant value to the slower pace of traditional board work when used for a specific education purpose (Jewitt et al., 2007). Increased lesson flow may also minimize the amount of teacher-student dialogue and result in shorter student responses (Gillen et al., 2007) and less time allotted for group work activities (Smith et al., 2006). It is up to the instructor to be judicious about when the increased pacing is appropriate and when it would be best to use alternative strategies.

Finally, to counteract the tendency to perpetuate the traditional lecturing model, teachers must actively design lessons to incorporate learner interaction and active participation. According to Hennessy et al., "The relationship between technology and interpersonal classroom interactions has emerged as critical" (2007, p. 298). An open communication channel between teachers and students must be established (Schmid, 2006). Jewitt et al. (2007) identified the paradox in which teachers want to elicit more student participation by having students come up to the board, resulting in the remaining students falling more into the spectator role. Teachers need to move beyond encouraging just technical or physical manipulation of the equipment, but rather aim for conceptual interactivity as described by Jewitt et al. (2007), where the focus is redirected to the exploration of curriculum concepts.

Discussion and Conclusion

Though use of IWBs in educational settings has been growing over the past two decades, the prior research surrounding the effectiveness of IWBs on learning has been primarily anecdotal until recently. Only through the government-funded initiative in the United Kingdom have we been able to have large-scale studies to conduct more rigorous analysis. These studies revealed that there is a conflict between the anecdotal information versus the empirical evidence that indicates that the initial motivation and engagement engendered by IWBs may not be

translating into substantial academic gains.

As a result, continued research on IWBs is needed. Administrators and policy makers have a vested interest in identifying which professional development strategies are most effective in helping teachers adapt to the new technology and pedagogy required to be successful. More studies should be conducted to determine the effect of IWB use on learner outcome when compared to traditional teaching methods.

Since the existing research centers on students in the K-12 and university settings, studies should also be conducted to determine if the positive effects on learner motivation, engagement, and achievement are true for adult audiences as well. This recognizes the fact that though much of the existing research involving younger participants can be applied to adult learners, differences still exist and adult learning needs and motivations must be addressed. Because IWBs have been installed in many school environments, teachers who participate in onsite professional development become an ideal audience to analyze. This analysis should identify the best practices related to IWB use among adult learners and determine whether IWB technology can be used effectively to deliver teacher training.

Smith et al. (2005) raised the question of whether the growth in the use of interactive whiteboards represented a boon for education or just another instance of educators getting on the latest bandwagon of technology. Only further research will answer this question and help to determine if interactive whiteboards are worth the continued investment of time, energy, and resources.

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