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History and Implementation of Classroom Technology

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Abstract

A plenary review of the research literature is provided regarding the history of K-12 classroom technology. Coverage is provided from the era of early “teaching machines” to the SMART technologies of Interactive White Boards (IWB). A chronology is traced, noting the development of technology and how teachers and administrators have adapted to the classroom milieu over decades of time. We also describe what the research literature demarcates as empirical benefits, liabilities, limitations, and suggested practices for classroom teachers who utilize technology in their respective classrooms. The presented paper is based on data from a master’s thesis regarding classroom technology in public school settings.

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1. Introduction

Technology permeates our nation. Interactive whiteboards (IWBs) are just one specific aspect of technological history. The implementation and utilization of the IWB in many schools across America today has impacted the lives of many students. Some may wonder how technology is used in American classrooms and even question its necessity or effectiveness. A broader look at technology and its impact on education helps place the IWB technology into its proper context.

2. Education and technology

Technology is rapidly changing the way we live and work. The field of education is no exception. In fact, during the late 1990s, new technologies were being invented and designed almost monthly. Technology was abuzz and education was the primary target for those eager researchers who wanted to see if their product could transform education as we know it. Almost a decade later, the novelty of educational technology has somewhat worn off. Many schools are struggling to make ends meet, cutting costs wherever possible. Financial struggles are still a reality today for many school districts. Yet even for those schools with limited financial resources, educational technology is still a prevalent part of education today (Vail, 2003).

Over the years, our nation has felt the pressure from other countries who are continuing to successfully integrate information and communication technologies (ICTs) into the education of their students. In order to prepare our students to thrive in the digital age, the United States has made a commitment to provide students with the skills and resources they will need to succeed in life (CEO Forum, 2001). According to the CEO Forum, educators are encouraged to make the best use of available technology in order to benefit our nation’s

schools, surrounding communities, and most importantly, our students. Today's students need to be taught twenty-first century skills that they will need in order to thrive in the future. Some of these skills include digital literacy, inventive thinking, effective communication, teamwork, and the ability to create high-quality projects. In order to do reach this lofty goal, educators need to focus technology on the key building blocks of student achievement. Those building blocks include assessment, alignment, accountability, access, and analysis.

Just as educators should consider the building blocks of student achievement, it is also important that they consider the many facets of education. One vital aspect to reflect on is how students learn. When teachers know how their students learn best, real authentic learning begins to take place and students are prepared and equipped for their future. Driscoll (2002) argued that while technology integration in schools is not easy, it is necessary. She provided four broad principles as a framework for teachers as they think about how to integrate technology into their daily instruction. These four principles were as follows: 1) Learning occurs in context, 2) Learning is active, 3) Learning is social, and 4) Learning is reflective. It is important to remember that technology by itself will not guarantee true learning. However, the proper use of available technologies does have the power to enhance and transform education in today's classroom.

Even with all the positive assumptions about the effective use of technology in the classroom, technology still tends to be viewed almost timidly by many educators today. Educators are often inclined to be traditionalists; therefore, they are not as eager to latch on to the newest and latest technological advancement that has just come out on the market (Vail, 2003). Another factor that contributes to educators' hesitancy in regards to technology is that they don't want to embrace a new technology until they see a need for it. With the passing of the No Child Left Behind Act (NCLB) in 2001, however, educators' perspectives were bound to change. In fact, Vail argued that it would be nearly impossible for schools to meet the demands that are placed upon them without implementing technology in the classroom.

As with any issue, there are usually two sides of the coin. The same is true for educational technology. It is important to recognize the differences between the *quantity* of technology use (*how much* technology is used and *why*) and the *quality* of technology use (*how* technology is used and *why*). In past research, the focus has been mainly on the *quantity* of technology use. However, it is just as valid a question to consider the *quality* of technology use in schools today. In fact, recent research indicates that even when technology is used at a certain frequency, not all technologies are found to be beneficial, constructive, or helpful (Lei, & Zhao, 2007). It is important that educators realize that the simple use of educational technologies alone does not guarantee that teaching and learning will somehow be transformed. Teachers must use technology efficiently and bring new pedagogies to their instruction. The combination of new pedagogies with technology use is what leads to improved teaching and increased student learning (Sutherland et al., 2004). Lei and Zhao (2007) emphasized that technology is an artifact, a product, and a tool. It has the capacity to accomplish certain tasks, but that potential is only realized when it is connected with specific problems. In other words, someone must use the technology correctly and efficiently for any benefits to be experienced. Secondly, technology use is dependent on the context of the situation and is closely connected with the users. In other words, the same technology can be utilized in several different ways depending upon the purpose of the one who is using the specific technology. Thirdly, *technology use* is in constant change while *technology* is in a static stage. Finally, technology use allows original technologies to take on various forms and uses. Ultimately, technology use is technology-in-context. Levin (as cited in Lei & Zhao, 2007) suggested that there are four categories in which technology may be used. These categories are as follows: 1) technology as media for inquiry, 2) technology as media for communication, 3) technology as media for construction, 4) and technology as media for expression.

3. Benefits of educational technology

Generally speaking, educational technology helps to create a rich, student-centered learning environment with a vast variety of wonderful opportunities for student-centered learning (DenBeste, 2003). Furr et al. (2005) acknowledged the benefits of educational technology, including but not limited to enlivening the classroom setting, stimulating learning, providing immediate feedback for students, allowing students to work in small

groups with their peers (either in the classroom setting or globally), and creating a classroom environment where the teacher's role is that of facilitator rather than lecturer.

Another benefit that educational technology brings is increased parental involvement and teacher professional development. For example, with the aid of technology, parents are able to communicate with teachers and view their child's assignments, attendance, and work online. Furthermore, educators can engage in professional development through the use of technology as it is made accessible to them anytime, anywhere (CEO Forum, 2001).

Educational technology increases students' abilities to apply and produce knowledge for the real world. These real-life contexts can be presented with the use of technology, making the classroom come alive. As students are challenged to take ownership and responsibility for their learning, they find themselves becoming more and more engaged in the learning process than ever before. In fact, as students seek to access more information through technology, they are able to deepen their knowledge so that they can meet their own personal needs and interests. Technology presents a challenge to students to go beyond just accepting information because it was presented in a textbook. Students in classrooms where technology is implemented well will apply research skills and seek evidence to support what they are learning. (CEO Forum, 2001).

4. Limitations and disadvantages of technology

While educational technology has the potential to enhance both teaching and learning, it is clear that these technologies are not always used to their full capacity. The challenge remains to adapt teaching strategies to the new technologies in ways that elicit and increase student learning and understanding (Lawrenz, Gravely, & Ooms, 2006). Computer technology is simply a tool, just as is a language, or pencil and paper. While it has its many benefits, the educator should anticipate unplanned side effects (both good and bad) of educational technology that often surpass the original intentions (Furr et al., 2005).

Another major downside to using technology in the classroom remains the time issue. Instructing students in the use of technology and creating resources to use with instruction takes an enormous amount of time and effort. Furthermore, it is of utmost importance that educators choose the type of technology that best suits their educational goals. Technology used simply for the sake of technology may "look good," but it will most likely be pedagogically useless (DenBeste, 2003).

Educational technology can cause a "knowledge divide," as only some students have access to the educational tools and learning that foster developing the skills needed for the twenty-first century. This presents a challenge to both the state and federal governments to continue to monitor and eliminate inequities in regards to the accessibility to educational technologies (CEO Forum, 2001).

If educational technology is to be used effectively, schools districts must also provide sufficient and continuous professional development for educators so that they are knowledgeable with any technology that they are being encouraged to integrate into their classrooms (CEO Forum, 2001).

5. Technology brings change

Research on the impact of technology in education is relatively new, yet there is sufficient evidence that educational technology helps to bring about changes in the processes of teaching and learning in classrooms. For example, technology has the potential to transform the learning environment from one that is teacher-centered to one that is student-centered. Other changes brought on by educational technology include a problem and project-centered environment that is collaborative, communicative, and productive. All of these characteristics help to foster a digital learning environment where it is possible to develop the skills needed to live in the twenty-first century (CEO Forum, 2001).

While technology use is valuable and desirable in today's classrooms, there is a fine balance between spending too much time using technology and spending too little time using educational technologies. Research conducted by Lei and Zhao (2007) indicated that students benefitted from spending up to about 3 hours per day

using computer technologies, but when they spent too much time (over 3 hours) using computer technologies, the benefits seemed to be cancelled out and unrealized. This research indicated that although the amount of time spent using educational technologies may have a general effect on student achievement, another factor to consider might be how the students spent their time as they used these technologies. Once again, the *quality* of technology use seemed to be more important than the *quantity* of technology use.

As educators seek to teach with technology in order to prepare students for the future, it is imperative that new assessments are implemented which reflect the changing pedagogical practices. Educational technology provides a variety of authentic assessments so that students are presented with more challenging and engaging tasks that will measure higher-level thinking skills. New technological assessments provide a more holistic picture of teaching and learning over time (CEO Forum, 2001).

Technology does bring change, and there is a marked difference in the environment of a multimedia classroom (a classroom which integrates cutting-edge instructional technology to enhance students' learning and engage them in the use of multimedia to construct and convey what they have learned) versus a traditional classroom (a classroom equipped only with a chalkboard and pull-down ceiling screen). Does either environment make a more positive impact on the students' perceptions of the learning achievement of students or on their perceptions of the instructional technology? A recent study which compared the perceptions of college-aged students who took classes in multimedia classrooms and students who took classes in traditional classrooms claimed that there were no considerable differences. However, the researchers did find that the students who were enrolled in the multimedia classrooms had more positive perceptions of their instructors' teaching methods than those students who took classes in the traditional classroom. Students who were interviewed at the end of the study commented that while technology can help the learning process, ultimately it is the instructor who makes the difference. Other students claimed that it was easier to pay attention and the lessons were more interesting when the instructor used a variety of multimedia teaching tools rather than relying solely on the textbook. Students also shared that using technology made the information seem more real. They felt that the media being used gave them an advantage over other students taking the same class in a traditional setting (Zhang & Deng, 2004).

While technology does incite change in the classroom environment, Kirkwood and Price (2005) challenged teachers and school administrators to continue to develop a better understanding of technology and the issues that often surround it so that innovations are not driven by technology alone. Technology is an important aspect to consider, but it is just as vital to consider educators' access to pedagogic models and processes as well as the contexts in which the students engage with technology. Technology by itself is unlikely to improve education. However, learning can be enhanced greatly when new innovations take the characteristics of the new technology and the pedagogic design into account along with the context within which the learning is taking place, the students' characteristics and their previous experience, and their familiarity with the technology involved. Technology on its own cannot ensure that effective learning outcomes are achieved; rather it is the educational purposes set out by the educators that must lead the way.

6. Overview of information communication technologies (ICT) in education

Most educational technologies today fall under the category of Information Communication Technologies (ICTs). ICT covers any product that can store, retrieve, manipulate or transmit information electronically in a digital form. Some examples of ICT include Microsoft Word, Excel, PowerPoint, Adobe Indesign, Photoshop and Illustrator, email, video conferences, digital cameras, CD-ROMs, fax machines, and of course, the World Wide Web (Introduction-What is ICT, 2006; Williams et al., 2000). ICT is a multi-faceted and resourceful tool that is not easily classified in nature or function. However, it can be compared with other educational resources like books, posters, worksheets, and videos which help stimulate, structure, and support learning activities in the classroom. ICT is not meant to replace these more traditional tools of education. In fact, there are some cases where the traditional approach may be more suitable. However, when integrated effectively, ICT can be used in

combination with traditional resources in order to provide the best learning environment possible (Kennewell et al., 2008).

As mentioned earlier, ICT is simply a tool for educators to implement and integrate into their daily instruction. As research shows, ICT is not a means in and of itself. ICT does not cause learning to take place. As one teacher shared in an interview, ICT is simply another tool. It is the teacher's responsibility to take the time to learn how to use it effectively (Sutherland et al., 2004).

ICT integration in classrooms is becoming more and more prevalent in schools today. Every classroom, however, has its own unique culture which ultimately affects how ICT is integrated and implemented into daily instruction. The classroom culture is influenced by a vast variety of people and circumstances. There are national and global influences, not to mention the influences of the school culture and subject culture. Outside cultures that the students bring with them to the classroom must also be considered. As teachers attempt to integrate ICT into their daily instruction, they often adapt their teaching strategies in ways that will fit with the particular culture or cultures in which they find themselves. A good example of this need to adapt ICT to a particular culture is found by comparing how elementary teachers implement ICT in their classrooms versus how secondary teachers implement ICT in their classrooms. For example, in a recent study, Sutherland et al. (2004) found that elementary teachers were more apt to create communities of learning where both students and teachers tapped into a wealth of ICT tools to construct knowledge. The researchers claimed that this may be in part because primary teachers often fail to see themselves as experts in a particular subject domain as secondary teachers often do. Consequently, primary teachers may have an advantage in that they are more prone to favor a co-construction of knowledge approach which is ideal when integrating ICT in the classroom. Williams et al. (2000) also researched ICT usage among both elementary and secondary teachers. Their research showed that both elementary and secondary teachers made use of ICT in the classroom context. However, their study reported that while both elementary and secondary teachers used ICT at a similar frequency in the classroom, secondary teachers used ICT more in the areas of professional development, personal use, and administration.

When considering how ICT is used in schools today, it is also important to consider the teachers' personal attitudes and the cultural perceptions of technology that they bring with them to the classroom. Albirini (2006) conducted a study to determine high school EFL teachers' attitudes toward ICT in Syrian education and then investigated the relationship between their attitudes and the factors thought to be influencing them, one of those factors being cultural perceptions. He discovered that most of the teachers felt that computers would contribute to improving their standard of living. These teachers also shared that they felt knowledge of computers would earn them the respect of others and ensure them certain privileges. His findings were not all positive, however. Albirini also found that while his respondents found ICT to be appropriate, they felt that there were other social issues that should be addressed first. The same teachers also commented that computers are propagating too fast and that an alternative computer might better suit their Arabic culture and identity.

Williams et al. (2000), found a significant correlation between levels of ICT use and teachers' attitudes. Their study showed that those teachers who were more inclined to see the benefits of ICT use for themselves and their students tended to use ICT more often. Those teachers who were prone to experience problems and worries tended to use ICT less because the difficulties and mishaps seemed to outweigh the possible benefits. Interestingly, Williams et al. also found that attitudes toward ICT varied among subject teachers. Their study showed that those who taught mathematics or science had a more negative attitude toward ICT, while those teachers who taught business and management classes had a more positive attitude towards ICT. ICT use does depend on many factors, as mentioned above. A few other factors that contribute to ICT use in the classroom include the availability of computers at home and/or in the teacher's personal time. Another factor is the availability of portable computers for use in the teacher's own time. In the end, Williams et al. found that teachers are ultimately the most important agents of change in the classroom.

7. Implementing ICT in today's classrooms – the benefits

There are many benefits of implementing ICT into today's classrooms. It is important to consider both student perceptions and teacher perceptions when analyzing the benefits of ICT.

Students' perceptions of ICT have been a focal point of research in regards to ICT usage in today's classrooms. Kirkwood and Price (2005) saw the significance of understanding students' perceptions of ICT because they claimed that the educational benefits that the students perceived as gains from using ICT were more important than the inherent characteristics of any particular product or medium.

Beauchamp & Parkinson (2008) conducted a study in a rural part of Wales in the United Kingdom. Their study began in an ICT-rich primary school setting and ended in a secondary school with fewer ICT resources. The study was conducted in order to determine if students' attitudes towards school science changed as they transferred from an ICT-rich environment to one with fewer resources. Their interviews with the primary students gave some valuable insight to student perceptions of ICT in the classroom. Some of the students' perceived benefits of an ICT-rich environment were better visibility and increased student participation.

Teachers' perceptions of ICT use have also been researched in many different studies. Williams et al. (2000) found that half of primary teachers and 69% of secondary teachers reported that ICT has had an impact on their teaching, although there were some variations on the secondary level between different subjects. In regards to the impact of ICT on students' learning, the majority of teachers (62% of both primary and secondary teachers) thought that ICT had a positive learning effect. Albirini (2006) found that teachers had positive attitudes towards ICT and perceived it as an asset to education. They viewed ICT as a viable educational tool that has the potential to bring about improvements not only to their own classrooms but to their whole school community. Albirini also found that teachers' perceptions of the compatibility of ICT with their current teaching practices were not as positive. Many teachers in his study were unsure about whether or not computers fit well with their curricular goals. Teachers also felt that their class time was too limited for computer use.

8. Implementing ICT in today's classrooms – the barriers

Implementing ICT into classroom instruction is not without its barriers and limitations. According to Williams et al. (2000), the main reason given by primary teachers for not using ICT was the lack of availability of ICT resources. Access to technology tended to override all other factors in determining the amount of ICT implementation.

There are, however, other factors that inhibit ICT use in the classroom. For example, Albirini (2006) noted that many teachers felt inadequate when asked about their computer competence. Because many teachers lack confidence in regards to using computers and other forms of ICT, it naturally follows that there would be some hesitancy on behalf of teachers who are required to implement ICT into their daily instruction. Other similar barriers given by primary educators are a lack of familiarity with ICT resources and a lack of skills in order to implement them effectively (Williams et al., 2000). Consequently, this lack of confidence deems that education administrators make the extra effort to provide training sessions and professional development in regards to ICT use before these teachers are expected to use the technologies in their classrooms. These training sessions, however, add an extra financial burden to many school districts.

Another barrier to ICT implementation perceived by the teachers was the mismatch between ICT and the current curriculum and the class time frame. Simply having access to computers was not enough to achieve educational change. Teachers would benefit from additional planning time so that they could experiment with new ICT technologies (Albirini, 2006).

It would seem that cost or lack of technical support would be strong inhibiting factors to ICT use in the classroom. In many situations, that may be the case. For example, Venezky (2004) reported that one of the three main barriers to ICT adoption in schools was infrastructure limitations, which especially included technical support. Some of the other infrastructure limitations were the placements of the computers as well as the

policies that govern student and teacher access to those computers. Yet, Williams et al. (2000) found that these factors were minor compared to the lack of availability and lack of access to technological resources.

9. ICT brings change

As previously mentioned, there are benefits and barriers to implementing ICT in the classroom. In order to implement ICT effectively, change is inescapable. According to Wheeler (2001), new technologies have provoked an entirely new and positive dimension to the art of teaching and learning. These changes, in turn, require a great investment by educators in the areas of time, effort, and overall commitment.

Successful implementation of ICT requires a balance between both the school's infrastructure and the competencies of its teachers. During the initial stages of ICT implementation, it is of utmost importance to have a reliable and user-friendly infrastructure to work with. However, as teachers become more technically competent, the shift towards more training opportunities in regards to ICT implementation and pedagogical abilities is necessary. The research shows that the most beneficial staff development programs were the ones that taught both ICT skills and related pedagogical skills (Venezky, 2004). A study conducted by Williams et al. (2000) asked teachers to share ideas for how to make future ICT training more effective and beneficial. According to these teachers, future training sessions should be flexible, allowing teachers to choose trainings that best fit their needs. These sessions should also be designed to increase familiarity with a wide range of ICT resources, and they should be focused on the types of ICT resources that are currently available in their school.

While there is definitely a need for training in regards to ICT development among teachers, Venezky (2004) argued that equal emphasis needed to be placed on administrative training for knowledge management, teamwork, and communication relations among teachers and administrators. Beyond these changes, it is also vitally important to learn how to create an environment where students feel safe to try new things and make mistakes. In order to successfully implement ICT in the classroom, teachers and administrators must remember that whether we embark on a new journey to include ICT resources, or whether we circle back to more traditional methods of teaching, the end result of the efforts made will ultimately be not from the power of ICT, but the power of the creative and imaginative mind that is willing to think "outside the box" to create the best learning environment possible for the students (Venezky, 2004).

Ultimately, ICT causes fear for some educators because technical education can seem to be overwhelming, compared to the more traditional forms of education. While ICT implementation does bring change to the classroom, Venezky (2004) suggested that a balance is needed between activity-laden projects and virtual experiences versus more traditional forms of learning, such as lectures, practice sessions and classroom discussions.

ICT implementation also brings changes for the teacher in the classroom. One way teachers must change is quite obvious. With the introduction of ICT into the classroom, teachers must learn how to apply these new technologies effectively in their efforts to improve their teaching as well as their students' learning. These changes are comprehensive and cover methodology, assessment, tracking, record keeping, communication, and curriculum evaluation. Teachers may also struggle with collaborative learning and sharing resources and working spaces. One of the most critical issues is the extent to which teachers will relinquish control so that their students can drive their own learning. Encouraging students to use computers gives them power to access, manipulate, modify, store, and retrieve information which ultimately gives them more autonomy in the classroom (Wheeler, 2001). While the implementation of ICT does encourage students to be constructors of new knowledge, Sutherland et al. (2004) stated that students still perceive their teacher as the knowledge provider simply because of the tradition of schooling. Regardless of students' perceptions however, there are times when a students' knowledge about using ICT technologies will exceed the teacher's knowledge. This can prove to be intimidating for teachers and cause them to fear the implementation of ICT in their classrooms. Yes, the role of the teacher will change, but Sutherland et al. (2004) argued that ICT does not simply change the role of the teacher from "teller" to "facilitator." They viewed the teacher's role as a gradual shifting of perspectives from the "more knowledgeable-other," to the "co-constructor of knowledge," to the "vicarious participant." In

other words, sometimes the teacher's role is to lead the students, sometimes it is to interact and engage the students in conversation, and sometimes it is to remain silent.

According to Wheeler (2001), there are four main ways that the teachers' roles will change as they integrate ICT into their classrooms. First of all, because ICT will make some resources obsolete, teachers will need to employ electronic forms of distributed communication. Secondly, ICT will most likely make some forms of assessment redundant and unnecessary. Certain forms of traditional testing will eventually be replaced with computer-based assessments. Thirdly, as mentioned before, it will no longer be sufficient for teachers to merely impart knowledge. Teachers will be expected to encourage thinking skills, promote information literacy, and nurture collaborative working skills to prepare their students for the outside world of technology. Finally, teachers will need to move beyond the traditional linear method of teaching and design lessons with non-linear elements.

The use of technology in the classroom presents a need for a healthy balance between whole-class and individual/group work. With the implementation of ICT, it is often assumed that individual and group work will replace whole class work. Sutherland et al. (2004) argued that a balance between the two is a key aspect to successfully implementing ICT into school subjects. While using some forms of technology seem to be more suitable for individuals or small groups, the same technology can be used to benefit the whole class as the students use it to present what they have learned. The sharing of student work with the entire class is helping teachers and students to shift from individual knowledge to collective and shared knowledge.

The use of ICT brings up the issue of interactivity in the classroom. Kirkwood and Price (2005) claimed that ICT has been transforming the nature of long distance education for individual learners in various ways. ICT has introduced a new level of interaction that previously had been difficult to achieve. Software related to the subjects being taught can engage students with new learning activities across a wide range of disciplines. Furthermore, the Internet enables two-way communication to be enhanced, making dialogue not only possible with other pupils but with tutors as well. As the student body becomes more diverse, teachers at all levels of education (elementary to secondary and especially beyond) will need to be aware of their potential learners and their familiarity with ICT as well as their ability to access it from home.

Interactivity is a term that educators are familiar with, but it has many facets. In fact, Hargreaves et al. (2003) came up with 9 different types of interactive teaching constructs. As they interviewed teachers' perceptions concerning interactive teaching, they found that they offered several conceptualizations of interactive teaching especially in reference to different purposes and contexts. While ICT does encourage a sense of interactivity, Tanner and Jones (2007) saw the importance of considering the differences between technical interactivity, pedagogical interactivity, and conceptual interactivity. Technical interactivity simply refers to the student's interaction with ICT (i.e. manipulating text and images). Pedagogical interactivity and conceptual interactivity are more in-depth. Pedagogical interactivity is necessary for effective teaching while conceptual interactivity is essential for effective learning. Their study showed that ICT was popular among the students involved in their study, but their interest was mainly concerning the superficial features of the technology. Oftentimes, interaction in whole class settings is teacher dominated as the teacher asks questions and the students quickly give a response (Burns & Myhill, 2004). The students that Tanner and Jones (2007) interviewed gave evidence that the quality of teacher-pupil interaction was the most important factor for significant learning. ICT alone did not contribute to pedagogical or conceptual interaction.

According to Venezky and Davis (as cited in Venezky, 2004), ICT rarely acts by itself as a catalyst for change in schools. In other words, simply implementing ICT in schools does not guarantee that schools will change their approaches to teaching or change some other major aspect of education. However, ICT can be a powerful lever for actually reaching planned educational innovations that were previously set goals. ICT has helped to reach goals that were essential for overall change, but it was not the cause for that change. ICT simply cannot be added to a particular educational situation and be expected to solve its problem. In order for ICT to be a lever for change, someone must first set a goal or a vision for change and then implement ICT in order to meet that goal. When used properly and efficiently, ICT can prove to be very powerful. With the use of ICT, schools can access a vast array of resources; form learning communities by connecting with families and teachers; give

students opportunities to work outside of class from anywhere that they have Internet access; and bring in experts from around the world (Venezky, 2004).

10. Interactive whiteboard

The interactive whiteboard (IWB) is a branch of ICT that has played a huge part in transforming today's classrooms. The IWB is large touch-sensitive board that controls a computer that is connected to a digital projector (Smith, Higgins, Wall, & Miller, 2005). The IWB is sometimes referred to as an electronic whiteboard or SMART Board. In 1991, a pioneer company called SMART Technologies produced the first SMART Board interactive whiteboards. Since then, IWBs have come a long way and many schools have these special whiteboards in their classrooms (SMART Technologies, 2006).

The IWB is a technological tool that has great potential. Smith et al. (2005) researched IWBs and came to the following conclusion: The IWB is not only a tool to enhance teaching, but it is also a tool to support learning. Beeland (2002) stated that the IWB is a tool for delivering instruction in a variety of ways that fall into one of three modalities of learning: visual learning, auditory learning, and tactile learning. The IWB helps students who are visual learners by providing them with a variety of visuals ranging from text and pictures to the use of animation and videos. Auditory learners also benefit from using the IWB through activities such as listening to sounds or music as part of a classroom presentation. Even tactile learners find the IWB helpful as they physically interact with the whiteboard by touching and moving things on the screen (Beeland, 2002).

Generally speaking, you can perform a variety of different functions with the IWB. For example, you can write, erase, and perform mouse functions with your finger, a pen or any other object that has a firm maneuverable surface. You can write in digital ink over websites and other applications. You can save your work or your notes and move them into a different software application. In the latest version of the IWB, you can even download software onto a personal computer. This is a great advantage for teachers because it allows them to create lessons from home. Furthermore, it allows students to review lessons and complete their work from home, provided that they have access to the Internet (Starkman, 2006).

Beyond the three different learning modalities that the IWB promotes, there is a variety of other more specific ways that the IWB can be used in the classroom setting. According to Reardon (2002), the IWB can be used to record class notes and homework assignments; prerecord a daily lesson; connect a whiteboard to a computer and the Internet; and integrate software programs into instruction. Ziolkowski (2004) surveyed some teachers in his local high school and found some creative ways that the teachers implemented the IWB in their classrooms. Ziolkowski used the "notebook feature" of the SMART Board to import images into his physics class. Other teachers made lessons ahead of time, saved them, and then used them repeatedly to demonstrate skills that the students needed to know and understand. A language arts teacher imbedded a variety of images, sound clips, and movie clips into his lessons, which were mostly downloaded from Internet searches. Gillen et al. (2008) researched the use of the IWB as a resource in a primary science classroom. They found that the teachers in their study used the IWB to present their objectives at the beginning of the lesson. Shenton and Pagett (2007) found that language arts teachers made pre-prepared screens so that they could scaffold and modify writing, using the IWB's tools to highlight texts in color and magnify them for closer perusal. Teachers also saved work only to return to it later and review it with their students. As previously mentioned, sometimes they also downloaded resources from the Internet to use with their lessons. Multimodal texts such as hyperlinks to other websites were commonly used as well. Villano (2006) found that teachers can manipulate a variety of tools that enables them to present slides, take notes, write in digital ink, control applications on a computer, and save work to share at a later time. Beyond the classroom, Fletcher (2006) stated that while teachers can use the IWB for demonstrations and introductions to specific units, they can also capture that same information and present it on their websites so that students can view it at their leisure.

The IWB is ever evolving. One of the emerging forms of the IWB is the wireless tablet. This portable wireless tablet functions similarly to the IWB. Wireless tablets allow teachers to stand at a distance from the IWB and yet control what is displayed on the whiteboard for the students to see (Landis, 2005).

The term “e-teaching” is a unique term used to describe the new pedagogy that is evolving with the use of the IWB. E-teaching involves the use of ICT to enhance the art of teaching students. E-teaching allows teachers to make use of a wide variety of resources through one simple piece of equipment – the IWB (Kent, 2006).

Another emerging form of the IWB has proven to enhance the learning of deaf students as well as students with learning disabilities. Software called *SynchronEyes* has proven effective for deaf students. *SynchronEyes* allows a teacher to monitor each student’s computer screen as well as disable the mouse and keyboard controls when the students should be looking forward to the front of the room. Teachers can also choose for certain messages to appear on the students’ individual computer screens so they know when to stop working and look to the front of the room (Mackall, 2004).

11. Implementing the IWB

Implementing the IWB into the classroom setting will no doubt change the classroom culture. Glover and Miller (2007) researched the effects of implementing IWBs into all mathematic classrooms in secondary schools. After implementing this change, many other changes took place in these classrooms. Some of these changes included classroom organization; pupil-pupil interaction; teacher-pupil interaction; selection of software and other resources; the IWB as the focus for the activities; rapport between learners and the subject being taught; and pair, collaborative and group learning. According to these researchers, all of these changes appeared to generate a culture of learning within each classroom.

While implementing the IWB tends to change the classroom culture, it is just as true that the classroom culture plays a huge role in how well the IWB will be implemented into the daily routine of instruction. If the classroom culture is not supportive and fails to create an environment where both students and teachers feel safe to explore the IWB without fearing failure, successful implementation of the IWB will be hindered (Kennewell & Beauchamp, 2007). According to Kent and Facer (2004), socio-culture theory brings the culture of human action to the front and center. One must first realize that both the teacher and the students work within a local classroom that is influenced by local, national and even global factors. It is within this context that the teacher and students bring their own personal history of experiences which relates specifically to their previous cultures of learning and tool use. Knowing this, it is not surprising that when a teacher or a student is faced with a new technology, both are prone to make sense of it in terms of their previous knowledge and experience of older technologies.

In order to use the IWB effectively, Glover and Miller (2007) made the following suggestions: the classroom should be arranged in a way that the equipment complements rather than intrudes upon the learning environment; the lesson should include stimulating software in a stepped learning process with plenty of opportunities for pupil activity; and the teacher should be demonstrative, embracing, and aware of all students so as to present a lesson that engages and captures the students’ full attention.

Cox and Abbott’s study (as cited in Kennewell & Beauchamp, 2007) showed that when the IWB is effectively implemented, it carries a great opportunity to impact student learning. The key to effective implementation lies with the teacher, the pedagogical approach adopted, the ICT resources employed, and the learning objectives intended. Research has shown that the IWB can have a positive impact on learning. For example, the IWB engages students; promotes a longer attention span and better focus; provides visual and dynamic representations; improves student motivation; encourages the pace and flow of a lesson; and provides multimodality (Kennewell & Beauchamp, 2007; Smith et al., 2005). Other positive results of using the IWB include differentiation; reflection; collaboration; and retention and transfer of knowledge learned (Kennewell & Beauchamp, 2007).

If the IWB is properly implemented and perceived as more than a mere presentation tool, it can promote interaction in the classroom. The classroom teacher needs to recognize that the IWB can be used in this way and then use appropriate software that affords that positive interaction between teachers and students and between students and their classmates. An IWB can afford interactivity by encouraging students to make use of the different ways of manipulating the applications that are running on the screen. Interactivity can also be

increased as students and teachers both interact with the IWB through the use of the keyboard, the electronic pens, or from digital control devices from other parts of the room (Armstrong et al., 2005).

12. Benefits of using the IWB

The IWB is a unique piece of technology that allows both teachers and students to perform a variety of techniques as well as tap into a wealth of resources. Kennewell and Beauchamp (2007) found that teachers felt that the IWB was especially effective in gaining and then keeping their students' attention for longer periods of time. They also felt that the IWB's large display helped their students to focus on the content being taught rather than on the teacher or on their classmates. On a more practical level, teachers found the IWB to be a great advantage because it allowed them to make their resources and then save them for the actual lesson. Kennewell et al. (2008) also found that this technology made it easier for teachers to prepare material in advance, quickly retrieve it for classroom display, and then manipulate the items directly on the whiteboard. According to Kennewell and Beauchamp's (2007) study, teachers also felt that their students were more apt to get involved when they taught with the IWB. While at first it may have been overwhelming to develop lessons for the IWB, teachers found it much easier to navigate the IWB and prepare lessons over time as they had more opportunities to practice and familiarize themselves with this particular technology. Furthermore, by preparing and loading lessons in advance, teachers felt that the IWB helped to create a smoothness to their organizational activities and overall classroom management. Ultimately, the greatest benefit perceived by these teachers was the notable increase in the students' level of engagement in the lessons.

The IWB has a variety of features that makes teaching and learning more effective. For example, as primary teachers taught science lessons, they presented the vocabulary words on the IWB and then highlighted key terms in red to carry high-sensory modality and capture the students' attention. Another common feature implemented by these teachers was that of the 'block reveal' technique. This allowed the teacher to cover up parts of the IWB so that the students could only see parts of the information at a time. The 'block reveal' technique is a great way to manage the pace of the movement throughout the lesson (Gillen et al., 2007).

The IWB makes it possible for students to see not only what is portrayed on the IWB but also any changes or additions that are made with the electronic pens. The IWB is very similar to a chalkboard, but it carries the possibility of using color, images and even moving images. The IWB also makes it very easy for teachers to access a wide range of resources and materials to support instruction. Oftentimes the IWB is controlled by the teacher as she stands at the front of the classroom. However, there are handheld remote control devices available which allow the teacher to make changes on the IWB from anywhere in the room (Clyde, 2004).

According to Kelley, Underwood, Potter, Hunter, and Beveridge (2007), a genuine advantage of using the IWB is the ability of the teacher to face the class for longer periods of time for each lesson since PowerPoint and other software programs allowed the teachers to prepare a few extra visuals. Other benefits for using the IWB include the following: much clearer images and sounds; flexibility; and upward compatibility. Schweder et al. (2008) found that the IWB is also very mobile, making it more accommodating to students with special needs. The height of the IWB is easily adjusted so that it can accommodate those in wheelchairs or those who have other disabilities. Even students with hearing and visual losses are able to participate in various interactive whiteboard activities.

While the use of the IWB does not guarantee that a higher focus is being placed on learning, the benefits of the IWB do seem to support more effective teaching. For example, the IWB is reported to enable smooth transitions between activities; quicken the pace of the lesson; provide "seamless flow" from one teaching point to another; reduce the time spent on managing resources; and prepare the lesson for classroom presentation (Smith et al., 2005). Ultimately the IWB does add value to the classroom, but the value added focuses mainly on teaching more efficiently.

One of the major benefits of using the IWB is that this technology makes it extremely easy and convenient for educators to employ multiple modes of representation with one simple resource, the IWB. It could be argued that teachers could find the individual resources needed and implement them separately, but the IWB makes it

possible to accomplish all of those goals with just one piece of technology. As teachers make wide use of the many different forms of representation on the IWB, students generally become more engaged in the lesson being taught. The IWB itself does not accomplish this feat. Teachers ultimately have to take advantage of their students' interests and then engage them multi-modally so that they can create cohesion and continuity that might not be achieved in a more traditional setting where there seems to be more of a disconnect between disparate events. According to Smith et al. (2005), some of the potential benefits of using the IWB include the following: flexibility, multi-media/multimodal presentations, efficiency, the ability to model ICT skills, interactivity and participation in lessons, and ease in the planning and the development of resources. The IWB also helps to quicken the pace of lessons. Less time is spent moving from one idea to the next when the IWB is implemented because such a plethora of resources are found in this one piece of technology.

The use of the IWB has the potential to increase interaction between teachers and pupils, but this interactivity depends on the skill of the teacher (Jones, 2004). According to Knight, Pennant, and Piggott (2004), the interactivity of the IWB comes more into play as teachers move down the following continuum of teaching contexts: 1) teacher as demonstrator, 2) teacher as modeler, 3) teacher in control, 4) pupils in control with the teacher advising, and 5) pupils working independently. Gillen et al. (2007) discussed classroom interactivity, but they made a distinction between technical interactivity and pedagogical interactivity. In terms of technical interactivity, the IWB seems to make a much smoother presentation from one technology to another. Pedagogical interactivity, on the other hand, is a little more complex. Teachers who use the IWB often find themselves standing at the front of the room near the whiteboard, which often means that the teacher is more apt to lead to a more traditional style of teaching. However, a truly effective teacher will use the IWB in order to produce a lively, varied and complex interactive lesson where the students are actively involved in the manipulation of information.

13. Disadvantages and limitations of the IWB

As with any new technology, there are always disadvantages and limitations that hinder its use. One of the disadvantages of the IWB is that only one person can use the board at any given moment, which limits the amount of interaction that the teachers can have with their students at any particular time (Shenton & Pagett, 2007). Another disadvantage from using the IWB is that oftentimes the student's active involvement with the IWB during whole-class instruction slows down the pace of the lesson and can cause boredom for the other students (Smith et al., 2005).

If the IWB is to be used effectively in the classroom, teachers must be properly trained and then provided with the necessary support to continue implementing the technology available at their fingertips. According to Freedman (as cited in Clyde, 2004), the IWB is often underused because teachers lack the time to find and develop resources and materials to use in the classroom. As Shenton and Pagett (2007) noted, practical issues such as technical support and installation of new equipment, could prove to be very troubling if these issues cannot be acknowledged in a reasonable fashion. In order for the IWB to make positive changes in today's classrooms, there is sufficient evidence that professional development support must be provided frequently (Glover & Miller, 2007).

14. Teachers' and students' perceptions

Glover and Miller (2003) studied teachers' attitudes towards the installation of IWBs in their classrooms. Their research showed a variety of attitudes/perceptions among the teachers chosen to be a part of the study. They classified the teachers' attitudes into one of the following categories: the missioners, the tentatives, the luddites, the revolutionaries, the gradualists, and the reactionaries. Each category consists of teachers with certain characteristics. For example, the "missioners" are those teachers who have already implemented the IWB into their lessons and who strive to get other teachers involved in that way. The "tentatives" are those who are interested in the IWB yet are fearful because of their lack of knowledge. The "luddites" are those teachers

who have had trainings for how to use the IWB, but they are fearful of embarking on a new journey and putting forth the extra time and effort needed to use the IWB effectively. “Revolutionaries” believe that the IWB has value and they seek to find ways to get other teachers on board with them to use it effectively. “Gradualists” are teachers who are aware of the need to change, but they change slowly, over time. Finally, the “reactionaries” are those teachers who are fearful that the new technology would bring problems for the school so they use the current or potential resource problems as a means of deferring change. Based on this study, when administrators want to implement the IWB into their classrooms, they need to take into consideration the attitudes and perceptions of their teachers since the pace of change clearly rests in their willingness to jump on board and make the changes a possibility.

In a study conducted by Shenton and Pagett (2007), teachers’ perceptions on the IWB were researched in six British primary classrooms. Many of these teachers saw the IWB as a powerful, extra resource to support their teaching. The IWB allowed them to be more creative with their lesson presentations. Furthermore, the IWB helped them with classroom organization and time management. Because the IWB is so versatile, the teachers could accomplish a variety of tasks without the distractions that often result when one has to stop and pass out papers or change to another form of technology. One teacher in particular felt that the IWB had the potential to lead to more “whole-class, teacher-led lessons.” While most teachers felt that the IWB had great potential to engage students in the learning process, they did not deny the fact that there was always a tendency for them to dominate the IWB so that students were not as fully engaged with the IWB as they could have been had they had more of an opportunity to explore it on their own. The teachers also admitted that it took a considerable amount of time and effort to create materials to use with the IWB, especially for those teachers who were implementing this type of teaching for the first time. While teachers recognized that the IWB had a positive impact on students by motivating them to learn and stay focused, they also recognized that for some students, the IWB served as a distraction for them. These teachers then had the challenge of finding ways to help those students to stay focused.

Many of the students’ perceptions of the IWB are similar to those of their teachers. For instance, Shenton and Pagett (2007) interviewed students from six primary classrooms in Britain. The students said that they liked the IWB because they could use it to view pictures from the Internet and watch video clips. In another study of British primary students, Hall and Higgins (2005) found that students liked the IWB because it had a wide range of resources that were versatile and easy to use. They also seemed to enjoy the multi-media capabilities of the technology and claimed that these elements helped to gain and hold their attention during the class lessons. For example, the students were very interested in the visual aspects (color and movement) as well as the audio aspects (sounds and videos). The students interviewed in this study also commented that the IWB made learning more fun and enjoyable. While these students’ perceptions of the IWB were generally positive, they also shared what they did not like about the IWB. Some of the problems perceived by students included failings of the technology itself (i.e. the IWB “freezing up” or shutting down and the sunlight shining on the IWB, creating a glare on the screen). Another common perceived problem among the students interviewed was the need to reorient the board. Students also complained that the IWB is sometimes fuzzy and difficult to read. Finally, students expressed their desire to use the IWB more in the classroom if possible.

Wall et al. (2005) conducted a study in English primary classrooms to research students’ perceptions of the IWB in the classroom. Overall, the students claimed that the IWB assisted their understanding and learning and motivated them to engage in the lesson because of their desire to use the IWB personally. In regards to their teachers, the students in this study claimed that the IWB not only helped their teacher to explain certain concepts, but it also helped them to become more enthusiastic and innovative in their teaching. When asked to share some of the disadvantages of using the IWB, the students mainly focused on the technical reliability of the whiteboard and the associated equipment. Another negative comment repeated frequently was the need for reorienting the board in the middle of a lesson. Students also complained about waiting for the technology to start up.

Students with learning disabilities also prefer using the IWB. According to Mechling, Gast, & Thompson (2008), students who were interviewed said that they liked the IWB because they could see the words, it was easy, and it was fun.

References

- Albirini, A. (2006). Teachers' attitudes toward information and communication technologies: The case of Syrian EFL teachers. *Computers & Education*, 47, 373-398.
- 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, 457-469.
- Beauchamp, G., & Parkinson, J. (2008). Pupils' attitudes towards school science as they transfer from an ICT-rich primary school to a secondary school with fewer ICT resources: Does ICT matter? *Education & Information Technologies*, 13, 103-118.
- Beeland, W.D. (2002). *Student engagement, visual learning, and technology: A report on 10 years of ACOT research*. Retrieved February 14, 2009, from <http://education.smarttech.com/ste/en-US/News+and+research/Research/International/US/2002/Student+Engagement.htm>
- Burns, C., & Myhill, D. (2004). Interactive or inactive? A consideration of the nature of interaction in whole class teaching. *Cambridge Journal of Education*, 34, 35-49.
- Clyde, L. A. (2004). Electronic whiteboards. *Teacher Librarian*, 32, 43-44.
- DenBeste, M. (2003). Power point, technology and the web: More than just an overhead projector for the new century? *History Teacher*, 36, 491-504.
- Driscoll, M. P. (2002). *How people learn (and what technology might have to do with it)*. Syracuse, NY: ERIC Clearinghouse on Information and Technology. (ERIC Document Reproduction Service No. ED470032)
- Fletcher, G. H. (2006). *Imagine the possibilities* T.H.E. Journal.
- Furr, P., Ragsdale, R., & Horton, S. (2005). Technology's non-neutrality: Past lessons can help guide Today's classrooms. *Education & Information Technologies*, 10, 277-287.
- Gillen, J., Littleton, K., Twiner, A., Staarman, J. K., & Mercer, N. (2008). Using the interactive whiteboard to resource continuity and support multimodal teaching in a primary science classroom. *Journal of Computer Assisted Learning*, 24, 348-358.
- Gillen, J., Staarman, J. K., Littleton, K., Mercer, N., & Twiner, A. (2007). A 'learning revolution'? investigating pedagogic practice around interactive whiteboards in british primary classrooms. *Learning, Media, & Technology*, 32, 243-256.
- Glover, D., & Miller, D. (2003). Players in the management of change: Introducing interactive whiteboards into schools. *Management in Education*, 17, 20-23.
- Glover, D., & Miller, D. (2007). Leading changed classroom culture -- the impact of interactive whiteboards. *Management in Education (Sage Publications Inc.)*, 21, 21-24.
- Hall, I., & Higgins, S. (2005). Primary school students' perceptions of interactive whiteboards. *Journal of Computer Assisted Learning*, 21, 102-117.
- Hargreaves, L., Moyles, J., Merry, R., Paterson, F., Pell, A., & Esarte-Sarries, V. (2003). How do primary school teachers define and implement 'interactive teaching' in the national literacy strategy in England? *Research Papers in Education*, 18, 217-236.
- Introduction-What is ICT? (2006). Retrieved February 14, 2009, from http://www.tutor2u.net/business/ict/intro_what_is_ict.htm
- Jones, K. (2004) Using interactive whiteboards in the teaching and learning of mathematics: a research bibliography. *MicroMath*, 20, 5-6.
- Keller, T. (2008). *The reason for God: Belief in an age of skepticism*. New York, New York: Penguin Group (USA) Inc.
- Kelley, P., Underwood, G., Potter, F., Hunter, J., & Beveridge, S. (2007). Viewpoints. *Learning, Media, & Technology*, 32, 333-347.
- Kennewell, S., & Beauchamp, G. (2007). The features of interactive whiteboards and their influence on learning. *Learning, Media, & Technology*, 32, 227-241.
- Kennewell, S., Tanner, H., Jones, S., & Beauchamp, G. (2008). Analysing the use of interactive technology to implement interactive teaching. *Journal of Computer Assisted Learning*, 24(1), 61-73.
- Kent, N., & Facer, K. (2004). Different worlds? A comparison of young people's home and school ICT use. *Journal of Computer Assisted Learning*, 20, 440-455.
- Kent, P. (2006). Using interactive whiteboards to enhance mathematics teaching. *Australian Primary Mathematics Classroom*, 11, 23-26.
- Kirkwood, A., & Price, L. (2005). Learners and learning in the twenty-first century: What do we know about students' attitudes towards and experiences of information and communication technologies that will help us design courses? *Studies in Higher Education*, 30, 257-274.
- Knight, P., Pennant, J., & Piggott, J. (2004). What does it mean to "use the interactive whiteboard" in the daily mathematics lesson? *Micro Math*, 20, 14-16.
- Landis, M. (2005, March/April). Eight ways to integrate whiteboard into instruction. *Media and Methods*, 41, 4.
- Lawrenz, F., Gravely, A., & Ooms, A. (2006). Perceived helpfulness and amount of use of technology in science and mathematics classes at different grade levels. *Technology in Science and Mathematics Classes*, 106, 133-139.
- Lei, J., & Zhao, Y. (2007). Technology uses and student achievement: A longitudinal study. *Computers & Education*, 49, 284-296.

- Mackall, P. (2004). Interactive whiteboards enhance the learning experience for deaf, hard-of-hearing students. *T H E Journal*, 31, 64-66.
- Mechling, L. C., Gast, D. L., & Thompson, K. L. (2008). Comparison of the effects of smart board technology and flash card instruction on sight word recognition and observational learning. *Journal of Special Education Technology*, 23, 34-46.
- Merrett, S., & Edwards, J. (2005). Enhancing mathematical thinking with an interactive whiteboard. *Micro Math*, 21, 9-12.
- Ozel, S., Ebrar Yetkiner, Z., & Capraro, R. M. (2008). Technology in K-12 mathematics classrooms. *School Science & Mathematics*, 108, 80-85.
- Pountain, D. (2001). *The new penguin dictionary of computing: An a-z of computing jargon and concepts*. London: Penguin Books, Ltd.
- Reardon, T. (2002). Interactive whiteboards in school: Effective uses. *Media & Methods*, 38, 12.
- Schut, C. R. (2007). Student perceptions of interactive whiteboards in a biology classroom (Master's thesis, Cedarville University, 2007).
- Schweder, W., Wissick, C. A., & Mounce, A. B. (2008). Teaching content with interactive whiteboards. *Journal of Special Education Technology*, 23, 54-58.
- 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, 129-136.
- SMART Technologies, Company Info. (2006). Retrieved February 14, 2009, from <http://www2.smarttech.com/st/en-US/About+Us/Company+Info/History.htm>
- Smith, H. J., Higgins, S., Wall, K., & Miller, J. (2005). Interactive whiteboards: Boon or bandwagon? A critical review of the literature. *Journal of Computer Assisted Learning*, 21, 91-101.
- Starkman, N. (2006). The wonders of interactive WHITEBOARDS. *T H E Journal*, 33, 36-38.
- Sutherland, R., Armstrong, V., Barnes, S., Brawn, R., Breeze, N., Gall, M., et al. (2004). Transforming teaching and learning: Embedding ICT into everyday classroom practices. *Journal of Computer Assisted Learning*, 20, 413-425.
- Tanner, H., & Jones, S. (2007). Using video-stimulated reflective dialogue to learn from children about their learning with and without ICT. *Technology, Pedagogy & Education*, 16, 321-335.
- The CEO Forum on Education and Technology (2001). *School technology and readiness report: Key building blocks for student achievement in the 21st century: assessment, alignment, accountability, access, analysis*. Washington, DC: Author. Retrieved February 14, 2009, from <http://www.ceoforum.org/downloads/report4.pdf>
- Vail, K. (2003). School technology grows up. *American School Board Journal*, 190, 34-37.
- Venezky, R. L. (2004). Technology in the classroom: Steps toward a new vision. *Education, Communication & Information*, 4, 3-21.
- Villano, M. (2006). Picture this! *T H E Journal*, 33, 16-20.
- 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, 851-867.
- Wheeler, S. (2001). Information and communication technologies and the changing role of the teacher. *Journal of Educational Media*, 26, 7-17.
- Williams, D., Coles, L., Wilson, K., Richardson, A., & Tuson, J. (2000). Teachers and ICT: Current use and future needs. *British Journal of Educational Technology*, 31, 307-320.
- Zhang, S., & Deng, H. (2004). Perception of learning effectiveness in the multimedia classroom vs. the traditional classroom: A case study. *Media Review*, 11, 87-107.
- Ziolkowski, R. (2004). Interactive whiteboards: Impacting teaching and learning. *Media & Methods*, 40, 44-44.