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Interactive Whiteboard Technology: Impacts on teachers, teaching, and students

Taylor Edward Yost Pettis
Augsburg College

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Minneapolis, MN

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MASTER OF ARTS IN EDUCATION

AUGSBURG COLLEGE

MINNEAPOLIS, MINNESOTA

CERTIVICATE OF APPROVAL

This is to certify that the **Leadership Application Project of**

Taylor Edward Yost Pettis

Has been approved by the Review Committee, and fulfills the requirements for the Master of Arts in Education degree.

Date of Oral Defense: December 17, 2009

Date Completed: 1-30-2010

Committee:

Vicki L. Olson

Adviser

Joseph D. Erickson

Reader

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Acknowledgements

I would like to thank the participants in this study for their active involvement in my research and for helping me to truly understand interactive whiteboard technology and its potential. With their assistance I have reached a whole new understanding of these topics and their impact on teachers, teaching, and students.

I would also like to thank the Augsburg College faculty. I would especially like to thank my advisor Vicki Olson and the readers who participated in my project who showed great patience and provided helpful and meaningful feedback throughout my project.

Finally, I would like to thank my family for their support, encouragement, and affection. I could not have done this without you!

ABSTRACT

Interactive Whiteboard Technology: Impacts on teachers, teaching, and students

Taylor Edward Yost Pettis

November 17, 2009

Leadership Application Project

To investigate interactive whiteboards and their impact on teachers, teaching, and students, a research review along with a qualitative case study on interactive whiteboards was performed. The purpose of this study is to learn more about the use of interactive whiteboards and specifically examine how one high school has implemented the technology. The research concludes that interactive whiteboards have had an overall positive impact on teachers, teaching, and students. Influences were noted in the areas of classroom practice, teacher collaboration, teacher preparation, and communication with students outside of the classroom. The examples listed in the case study are exclusive to the high school in the study and may not remain consistent or relevant to other schools or educators. Information in this study was gathered through a series of interviews, classroom observations, and interactive whiteboard and technology demonstrations. It is my hope that readers of the case study will find value from the data collected and ultimately use the data to expand their interest in and ideas of how to use the technology.

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Introduction

Thomas Edison believed that films would replace books in schools. Edison lived from 1847 – 1931 and attended school prior to the twentieth century when instruction consisted primarily of the teacher, the textbook, and the chalkboard. The comments Edison made roughly a century ago have great merit, as technology continues to develop and rapidly change education learning environments. Advancements in computer technology, cell phones, video games, ipods, and other digital devices have changed how current students view the world. These new innovations are increasingly becoming part of the K-12 classrooms, as teachers incorporate more technology into their lessons. Computers, LCD projectors, and interactive whiteboards are widespread and frequently seen in everyday classrooms. Students' understanding of technology is increasingly important as the current generation of students will have access to more technological innovations than any other generation. For that reason, it is important that students become familiar with a multitude of programs to make them digitally literate and teachers will need to get them excited about new technologies.

K-12 classrooms are living, breathing, and evolving creatures. Similar to an animal in the wild, classrooms need to adapt with change in order to survive. The characteristic classroom that consisted of desks assembled in formal rows facing the chalkboard is a distant memory. Cooperative learning groups have changed the classroom layout and teaching practice that once consisted of questions about factoids from the previous day's lesson (Barnes, 2008). In addition to the esthetic look of the classroom, new interactive technologies have become a popular and effective teaching tool in classrooms (Nolan, 2009). Interactive whiteboards represent the perfect combination of education and entertaining technology; students in awe of the technical capabilities usually do not even realize they are learning (Nolan, 2009). In 2005, researchers Dr. Gary Beauchamp and Dr. John Parkinson referred to this as the interactive whiteboard "wow" factor. These technologies have reshaped how children learn and

prepare students to function in a technological world (Nolan, 2009). Chalkboards and overhead projectors are increasingly replaced by interactive whiteboards in today's classrooms. The adoption of these technologies has changed teaching practices and preparation, allowing teachers additional time and alternative technology tools to engage students.

My Leadership Application Project (LAP) studies interactive whiteboard technology and observes the impacts on teachers, teaching, and students. What is an interactive whiteboard? It is a large, touch sensitive screen that controls a computer-connected digital projector, effectively creating a 60-inch computer monitor for the teacher to use in the lesson. The technology was originally developed for office settings (Greiffenhagen, 2002) but has recently made the transition to education and the classroom. Interactive whiteboards are a seamless combination of numerous presentation styles. Using interactive whiteboards benefits all learning styles (Nolan, 2009). The appeal to visual learners is obvious, kinesthetic learners have the ability to come up to the interactive whiteboard and manipulate objects by clicking and dragging, and auditory learning styles can benefit from audio recording functions and audio software in the technology (Nolan, 2009). Interactive whiteboards function with a variety of accessories including clicker interactive remotes that that assist teachers in immediately evaluating student performance. Teachers can also post lessons and assignments to classroom websites and use interactive software and exciting graphics to capture students' interests. These interactive technologies are not only changing the appearance of the classroom, but the manner in which lessons are taught. Increased technologies, including interactive whiteboards, are a major component for Universal Design for Learning (UDL) teaching strategies as well as other best practices being developed within the field of education.

My LAP includes a review of recent research related to interactive whiteboards and their use in the classroom followed by a case study of a Saint Paul suburban high school that implemented

interactive whiteboards into every classroom in the building. The qualitative analysis of the school and its use of interactive whiteboard technologies was completed through a series of teacher observations, interactive whiteboard demonstrations, and interviews with teachers, administration, and the school district's technology specialist. The participants in the study were deemed as experts by their peers. Although the data and practices in the qualitative analysis are specific to one school, my hope is that teachers and others in the education field will see some parallels to their own education communities and the case study may serve as an indirect guide for best practices.

Literature Review

Education journals are filled with testimonials from teachers who affirm the positive statements about interactive whiteboards. However, these articles provide little quantitative data and consist primarily of qualitative analyses and personal assessments indicating support for interactive whiteboards. Due to the limited empirical evidence on this topic (Bennett & Lockyer, 2008), the literature review will primarily consist of qualitative analysis and case studies, as they are intriguing and provide good background information about the topic. I have also included books that provide general background on the changing face of technology in the classroom. Some materials included are not specific to interactive whiteboards, however I feel they provide valuable information that is related to implementing new, cutting edge technology in K-12 education. Each document is relevant to the study in analyzing K-12 technology trends, changes to teaching practice, student engagement, and student performance. The literature review is segmented into these relevant topics that align with LAP project to research interactive whiteboard technology and the impacts on teachers, teaching, and students.

Technology Trends in K-12 Education

Organizations often make changes to their operations and infrastructure. These changes are generally implemented to solve a problem or fulfill a need that is currently not being met. The same holds true for K-12 education and interactive whiteboard technology. Educators and schools must see the value provided prior to making any investment. My literature review includes two books, *Growing Up Digital* and *Disrupting Class* that describe the technology trends in K-12 education and support increased technology use in the classroom.

Don Tapscott (1998), author of *Growing up Digital* describes the rise of the Net Generation in his book. The Net Generation (N-gen) is roughly 80 million Americans ages 2 – 22 in 1999. The demographic of N-gen is the first generation in history to be more comfortable, knowledgeable, and literate with innovation and technology than their parents' generation. These digital savvy children know more about technology than their parents.

Tapscott states in his book that television has always been one of the most popular forms of technology. However, the N-gen watches less television than people five years older than them. These technology natives are searching for forms of interactive media, whereas television simply reports and lacks the communication and collaboration the N-gen craves. N-geners are drawn to interactive technology and use it to play, learn, communicate, and build relationships. Tapscott indicates that interactive technologies have made play productive. Interactive whiteboards speak the N-gen language.

Tapscott states that the N-gen is the largest generation and consists of 30% of the U.S. population. Barely inching out the Baby Boomers (29%), the N-gen has lapped their elder generation in terms of technology. Adults are typically viewed as the teachers of the next generation. That is an anomaly when it comes to technology. Tapscott states that children of the N-gen are now educating their elders on new technology. The social culture of the N-gen has also changed. Tapscott cites new methods of communication and friendship that includes pop culture, internet, wireless technologies, and means of social networking. These changes have led to new learning styles for the N-gen. Teachers will be forced to adapt to students' new interests. Teachers will have to change how they teach, "Rather than fact repeaters, teachers can and will have to become motivators and facilitators" (p. 154). Tapscott believes that educators will be forced to accommodate these changes to keep students' interest and help them remain up to speed with society and its use of technology.

The N-gen and students described by Tapscott indicate a quest for additional technology in the K-12 classroom. Student excitement for interactive media support implementation of interactive whiteboards by fulfilling students' desire to be engaged with technology. The features of interactive whiteboards stretch far beyond the standard video screen and television that once excited older generations. The N-gen uses interactive media as their primary method of entertainment and obtaining information about news, popular culture, and their friends. Furthermore, business and professional work environments now use multiple forms of interactive technologies and web portals that are similar to what K-12 students' use for entertainment. It is important that schools use multiple forms of technology in the classroom and teachers adapt their practices to meet the expectations of today's students and prepare them for the workforce of tomorrow. Implementing interactive whiteboards is a natural next step towards changing teaching practice and using forms of media that will excite and engage the N-gens.

Clayton M. Christensen (2008) authored a book *Disrupting Class, How Disruptive Innovation Will Change the Way the World Learns.* Christensen's disruption theory posits that without disruption there is no change, and without change there is no innovation. For Christensen "disruption" of the norm is positive as it leads to innovation. Christensen discusses products that are different than their predecessors as examples of disruptive innovation. The transformation from an IBM mainframe computer to personal computers and the evolution from a rotary phone to the cell phone are two such examples. Christensen states that the education field can and should learn from disruptive theory. New styles of teaching and technology used within the classroom will disrupt the cliché classroom models and more effectively impact students' learning.

Student centric learning is another Christensen term and an essential component to his definition of disruption. Christensen believes that these two elements are essential to student success. Student centric learning is a modular learning design that is the complete opposite of a monolithic

teaching process. Christensen feels that student centric learning is essential to improving the education system. Every student learns differently and at different paces. Implementing computer-based learning is a step in the road towards providing curriculum at a personalized pace for students allowing them to customize their own learning.

The use of technology in student centric learning will ultimately provide struggling students with a resource that is similar to a tutor. Christensen states that tutoring programs are rarely equally distributed among schools and socioeconomic status. Student centric learning will fill the gaps that have occurred between rural and metro, urban and suburban, affluent and poor, students who excel and those who struggle.

Finally, Christensen states his vision of a futuristic classroom bursting with technology. The vision imagines a student using international webcam buddies to study foreign languages and another student using an audio program to learn how to read music. The vision displays a learning environment where students are not bound by the teacher's limits, rather they are allowed to disrupt boundaries and learn from and through technology. In conclusion, Christensen asks readers not to place boundaries on what students may learn from classroom technology.

Christensen's classroom observations and ideas for new teaching methods support a transition of increased technology in the classroom. Interactive whiteboards will not be the end all, cure all for the student centric learning model suggested by Christensen, but the technology is a step in the right direction. Interactive whiteboards provide teachers with the ability to manipulate lessons, presentation methods, and review features that provide forms of customized learning for students. Interactive whiteboards are also compatible with a number of accessories including probes used in field research, such as temperature and force gauges that communicate directly with computers and provide independent learning environments and clicker interactive remotes that allow teachers to immediately

evaluate student responses. These add-on and additional features are just another natural step towards student centric learning as described by Christensen.

Teaching Practice

Multiple researchers have indicated a change in teaching practice with the addition of interactive whiteboards to the K-12 classroom. A study on the use of Audience Response Systems (ARS) was completed by Larry J. Barnes (2008). ARS systems are commonly referred to as "clickers" and they a sometimes used as a companion to interactive whiteboard instruction. As Barnes (2008) reports, his experiment was inspired by Thomas Lord's constructivist college teaching methods (Lord, 1998; Lord, 2001; Lord, 2005; and Lord & Orkwiszewski, 2006). Barnes (2008) states that this method transforms the classroom from a teacher-centered classroom focused on lectures to a more constructivist learning environment, defined by Dufresne, Grace, Leonard, Mestre, & Wenk, (1996) as "a set of beliefs about knowing and learning that emphasizes the active role of learners in constructing their own knowledge." (p. 531) Barnes' study included forty-three Idaho public high school biology students. The study was performed between November 27, 2006 and March 2, 2007. During this time, students learned the content of three units through both lecture-based and lecture free models. The lecture based models consisted of Power Point presentations that required students to work in small groups to complete worksheets that had fill in the blank answers for 10-20% of the worksheet text. The lecture-free model used Qwizdom brand ARS and had students complete 50-60 questions per unit while working in collaborative groups. Students in the lecture free groups were required to teach one another using a jigsaw model. Both teaching methods were evaluated through a series of ungraded tests that were given on the first and last day of each unit to test pre and post knowledge using both teaching methods. Results from Barnes' study indicated that lecture free classes had a slight increase in student performance that ranged from 1.7% - 2.6% increase over the lecture based curriculum. The more

impressive story is students' perception of lecture free learning using ARS. Barnes' table below lists student responses that included opinions of increased learning and rigor.

Anonymous survey results from 41 sophomores about lecture-free vs. Lecture-based teaching and the use of Quizdom remotes

	Agree	Neutral	Disagree
Anonymous survey results from 41 sophomores about lecture-free vs. Lecture-based teaching and the use of Quizdom remotes	51%	22%	27%
The "Lecture-free" approach was more frustrating than the "lecture-based" approach	44%	29%	27%
I feel that I learned more from the "lecture-free" approach than I did from the "lecture-based" approach	51%	20%	29%
I had to use my brain more in the "lecture-free" approach than I did in the "lecture-based" approach	68%	22%	10%
Working in small groups to answer questions on Quizdom is a better way to learn than working individually	68%	25%	7%
Rather than all "lecture-free" or all "lecture-based" approaches, I think a mixture of the two would be best	64%	29%	7%
Working in small groups to answer questions on Quizdom helps me learn more than taking notes from PowerPoint presentations	49%	32%	19%

Table 1. From "Lecture-Free High School Biology Using an AUDIENCE RESPONSE SYSTEM," Barnes, L. 2008 The American Biology Teacher 70 (9); p. 534

The results of Barnes' study indicate a correlation between changed teaching practice and student perception. Students using the lecture free model that required the use of ARS believed they had engaged in a more rigorous curriculum (table 1) and expressed an interest in using the ARS systems three to four times a week as part of their instruction (table 2).

Average percent increases between post-test and pre-test scores for lecture-free and lecture-based classes. Probability of determined by two-tailed t-test.

Unit	Number of days between pre-test and post-test #1	Lecture-Free		Lecture-based		
		Average gain	N	Average gain	N	P
1	14	18.8%	24	18.3%	18	0.42
2	26*	20.4%	17	12.3%	22	0.04
4	13	12.2%	19	13.9%	22	0.93
Units 1,2, and 4 combined	N/A	17.2%	60	14.6%	62	0.13
	Number of days between pre-test and post-test #2					
1	93	20.2%	25	18.9%	18	0.31
2	77	22.1%	17	20.6%	22	0.30
4	34	14.7%	18	13.0%	22	0.57
Units 1,2, and 4 Combined	N/A	19.1%	60	17.4%	62	0.64

*All unites were approximately 10-11 class days. Christmas break occurred in the middle of Unit 2. Post-test #2 occurred during finals week.

Table 2. From "Lecture-Free High School Biology Using an AUDIENCE RESPONSE SYSTEM," Barnes, L.

2008 The American Biology Teacher 70 (9); p. 534

3 Chart showing student preferences on the frequency of Qwizdom use.

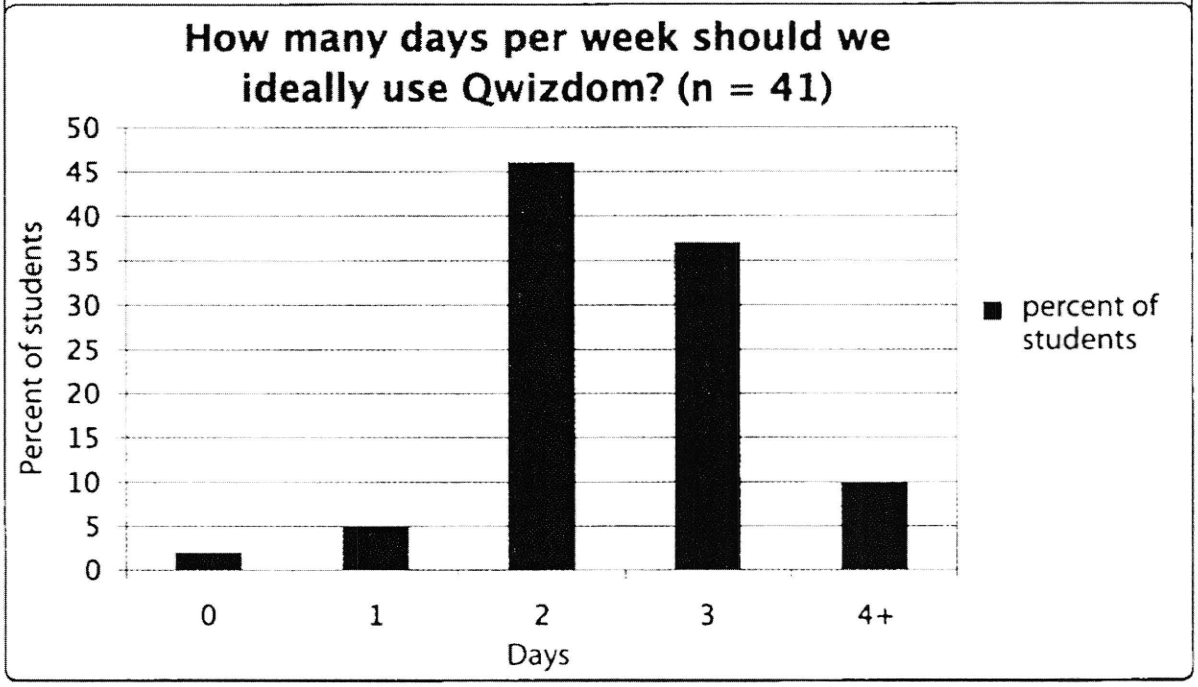


Table 3. From "Lecture-Free High School Biology Using an AUDIENCE RESPONSE SYSTEM," Barnes, L. 2008 The American Biology Teacher 70 (9); p. 534

Although the lecture free model did indicate a slight increase in student performance, I feel the range of improvement was too small to link interactive technologies including the companion tool of clicker interactive remotes with improved student performance. However, Barnes' study does serve as a model of alternative or new teaching practices using interactive whiteboard tools. Furthermore, the independent learning models used in the Barnes' study share some synergies with Christensen's student centric learning.

Interactive whiteboards have influenced more changes than the clickers (ARS) included in Barnes' (2008) research. Gary Beauchamp and John Parkinson (2005) conducted a research study, *Beyond the "wow" factor: developing interactivity with the interactive whiteboard* in 2005. Beauchamp and Parkinson's research was done at the start of the interactive whiteboard buzz. Their research indicates a similar student excitement for interactive whiteboards and its features as Barnes. The benefits they cite include:

- Increased motivation.
- Greater opportunity for pupils to participate and collaborate.
- Pupils are able to cope with more complex concepts as a result of clearer, more efficient and more dynamic presentations.
- Increased capacity to cater for different learning styles.
- Enables pupils to be more creative when making presentations to fellow pupils.
- Pupils do not have to use a keyboard to engage with the technology, increasing access to younger children and pupils with disabilities.

Table 4. From "Beyond the 'Wow' Factor: developing interactivity with the interactive whiteboard," Beauchamp, G. and Parkinson, J. 2005, School Science Review, 86 (316) p. 97.

Beauchamp and Parkinson (2005) indicate that interactive whiteboards are a lot more exciting than the blackboard and overhead projector, and pupils are curious to find out about its functions and capabilities. As a result, students pay greater attention in class than in the past (Beauchamp & Parkinson, 2005). However, this can be short lived. Once the teacher has exhausted all of the interactive whiteboard routines, and the "wow" factor diminishes and students may revert to less attentive behavior. Beauchamp and Parkinson include features and strategies in their research to assist teachers in maintaining student engagement. The table below includes a general matrix of interactive whiteboard features and software use that teachers may seamlessly transition into their lessons.

Exercising these features of the interactive whiteboard are clear changes to teaching practice, as each feature allows the teacher to manipulate data and presentations in ways that were not possible using other classroom technologies.

5 Interactive whiteboard software tools that provide teachers with opportunities to use distinctive teaching strategies

Ways of treating information	*Whiteboard features*
Capturing	Copy and paste from other software, e.g. *Word*, graphics packages 'Photograph' screen images
Emphasising	Tickertape function (a word or phrase continuously moves across the screen) Large text Spotlight function (the view is restricted to a circular area of the screen)
Storing	Storing on flipchart pages to be revisited later on in the lesson or in subsequent lessons Recording as flipchart files Storing in the link library
Annotating and modifying	Using the pen, sometimes in conjunction with other features such as arrows or lines, to add writing to existing images and text Using the highlighter pen Carrying out DART activities such as: – using drop and drag to match labels to features – rearranging objects or text into a correct sequence – cloze procedure exercises (a coloured pen is used to cover text and the whiteboard 'rubber' is used to reveal the hidden text)
Linking	Linking to other pages in the flipchart Linking to files stored on the computer, e.g. *Word, PowerPoint, Excel* Linking to programs stored on the computer, e.g. *Crocodile Clips*, concept cartoons, concept mapping software, *Kar2ouche* Linking to Internet sites

Table 5. From "Beyond the 'Wow' Factor: developing interactivity with the interactive whiteboard," Beauchamp, G. and Parkinson, J. 2005, School Science Review, 86 (316) p. 98.

Beauchamp and Parkinson state that interactive whiteboards are a focal point for students. The large screen generally draws their attention and provides a method to focus for them. Beauchamp and Parkinson list a variety of methods for teachers to use the interactive whiteboard pulpit to post assignments, classroom notices, and lesson objectives. Interactive whiteboards also spawn classroom

excitement. Prior to Interactive whiteboards, students were called up to the blackboard to answer questions using chalk or a marker. Now students use technology that induces the manipulating of objects and drag & fill activities to answer the same question (Beauchamp & Parkinson, 2005). Additionally, interactive whiteboards act as a stimulus for classroom discussion, leading to the production of new information. Beauchamp and Parkinson illustrate below (Note 5) how interactive whiteboards scaffold learning strategies and build sequenced discussions.

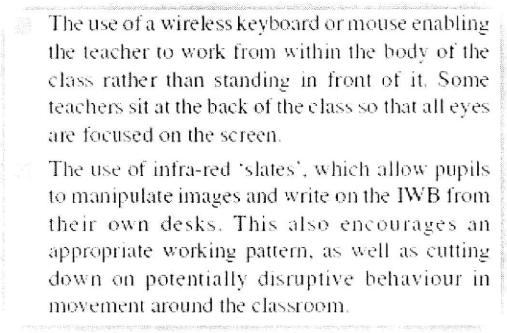
6 Part of a lesson sequence illustrating how a combination of IWB features can foster interactivity

Teacher input	*Group discussion*	*Group presentations*	*Confirmation of correct science*
The class observes a solid (e.g. stearic acid) being heated either as a simulation or using a data-logger. Running alongside the image of the heated substance is a table and graph plotting temperature against time. The changing phase of the substance is also recorded.	Groups are asked to explain what is happening to the particles as the temperature is increased. They are asked to prepare particle diagrams with a few words of explanation.	Each group presents its conclusions to the rest of the class using the IWB pen. Teacher and other pupils ask questions to clarify any points. No comment is made on the correctness of the information until all the presentations have been completed.	Teacher uses simulation software to explain particle movement at the various stages of heating and compares this with the pupils' suggestions. Where appropriate, the teacher discusses why the pupils' model is incorrect.

Table 6. From "Beyond the 'Wow' Factor: developing interactivity with the interactive whiteboard," Beauchamp, G. and Parkinson, J. 2005, School Science Review, 86 (316) p. 100.

Overall, the "wow" factor had an impact on teaching pedagogy. Beauchamp and Parkinson (2005) indicate that teachers are driven to change their teaching practices in order to maintain student excitement with technology. Immediate and seamless manipulation tools have provided teachers with the capability to change the direction of a lesson on the fly. The advanced tools of interactive whiteboards have changed teaching pedagogy. Teachers may now pull resources from the internet to assist with their presentations and lessons. This has changed teaching practice as the classroom has shifted from one dominated by teacher exposition to one where co-learning is seen as the prevailing

force (Beauchamp & Parkinson, 2005). While the initial impact of the whiteboard technology was the 'wow' factor for students, the long-term impact is on the pedagogy of teachers. Other practical measures that stemmed from interactive whiteboards and have changed teacher pedagogy include:



- The use of a wireless keyboard or mouse enabling the teacher to work from within the body of the class rather than standing in front of it. Some teachers sit at the back of the class so that all eyes are focused on the screen.
- The use of infra-red 'slates', which allow pupils to manipulate images and write on the IWB from their own desks. This also encourages an appropriate working pattern, as well as cutting down on potentially disruptive behaviour in movement around the classroom.

Table 7. From "Beyond the 'Wow' Factor: developing interactivity with the interactive whiteboard," Beauchamp, G. and Parkinson, J. 2005, School Science Review, 86 (316) p. 100.

Beauchamp and Parkinson (2005) believe that the most important impacts of whiteboard technology are the change in pace of lessons and transitions between different parts of the lesson, together with the greater attention teachers can give to their class by using the support of interactive whiteboards.

Tom Reardon from Austintown Fitch High School in Ohio would relate well to the "wow" factor and the research performed by Beauchamp and Parkinson. Reardon, a mathematics instructor, has used the interactive whiteboard in his classroom to record his class lectures and offer sample tests that he posts on his personal website for students (O'Hanlon, 2007). Using the record feature of interactive whiteboards, Reardon creates his own educational videos that are used to engage students in classroom activities. Reardon also created a video-on-demand to assist students in preparing for tests and states that the results of doing so are quantifiable. The interactive whiteboard assisted in Reardon's ability to

provide these online resources to his students. Reardon believes there is a link between increased student test scores and the use of interactive whiteboards. The additional learning tools and the alternative teaching practice are attributed to the increased student success (O'Hanlon, 2007). Reardon is an outstanding teacher who shared the methods of using interactive whiteboards to increase student access to materials. Teachers like Reardon inspire other educators to work harder and achieve more. Reardon's inspiration makes the case study of his classroom an important article for the literature review on interactive whiteboards.

Interactive whiteboards and changes to teaching practice extend beyond our American boarders. The United Kingdom (U.K.) has performed significant research on the topic of interactive whiteboards. The U.K. has become of considerable interest in this topic due to the massive influx of interactive whiteboards into schools supported by significant government funding (Bennett & Lockyer, 2008). In fact, Helen Smith's (2001) study was funded by the U.K Government spending. To complete Smith's research, the government purchased equipment including a 60" SMART Board with stand, and NED 1100 Lumens projector for each of the six schools that participated in the study. Smith's observations noted advantages for teacher preparation and delivery of instruction. One change in teaching practice and benefit of interactive whiteboards observed was that teachers were able to teach from the front of the room. In doing so, teachers were better positioned to observe pupils' responses (Smith, 2001). The Smith study also indicated that interactive whiteboards are effective for teacher led group work, but less effective for unsupervised group work. Smith observed that younger students had difficulties entering text onto the whiteboard both with the on-screen keyboard and the pens. She posited that the use of a cordless keyboard might serve as a band-aid to the problem (Smith, 2001). Clickers and ARS tools included in Barnes' (2005) research would be another companion feature and alternative for students to indicate responses on the interactive whiteboard.

Besides changes in teaching pedagogy, the use of interactive whiteboards has driven the use of new software. Australian researchers Sue Bennett and Lori Lockyer (2008) completed a qualitative study on the teaching practice of four primary school teachers. Their study was performed at a school in the outer suburbs of a major Australian city in an area of relatively high socio-economic status. The data collected through a series of interviews, classroom observations, and a use log indicated that the teachers used interactive whiteboards 70% of the time. However, the more interesting data from their study indicated a shift in the software they used along with the interactive whiteboards. The use of SMART Notebook software heavily increased, while productivity software such as Microsoft Word and Excel decreased with the use of interactive whiteboard technology. The table below indicates the percentage of interactive whiteboard time per software tool used.

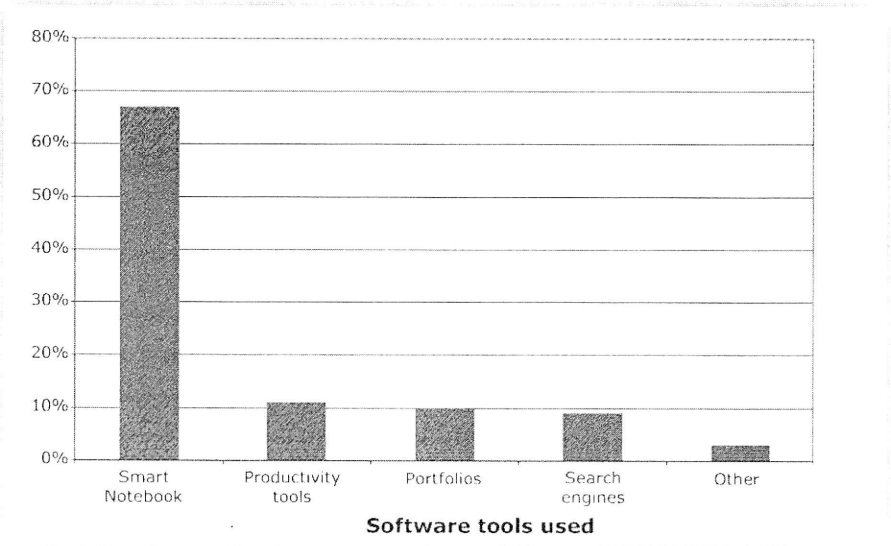


Table 8. From "A study of teachers' integration of interactive whiteboards into four Australian primary school classrooms," Bennett, S. and Lockyer, L. 2008, Learning, Media and Technology 33 (11), p. 293.

Bennett and Lockyer (2008) stated that "students had no difficulty using the interactive whiteboard, and were focused on their task" (p. 294). Their research indicated several other benefits

for the use of SMART board technology. Students in classrooms using the interactive whiteboard technology were unconcerned about the rest of the students' behavior and distractions. A teacher from the study cited that "accessing the internet on the interactive whiteboard was a benefit. The internet has added another dimension to teaching in the classroom that everyone can see from everywhere in the room and interact with" (p. 294). Other testimonials from the study include statements that interactive whiteboards offer efficiencies in terms of planning and lesson preparations. These statements were grounded by the belief that interactive whiteboards were quicker to prepare lessons, that uploading prepared lessons eliminated the need to write instructions on the board, that time was saved by moving between screens without rubbing out and re-writing, and that photocopying was significantly reduced. The teachers also found that the transition between lessons was quicker with the use of SMART Notebook software that enabled them to record classroom accomplishments and save outcomes on the school's intranet.

In this section of the literature review, I have documented research on interactive whiteboards that cites changes in teaching practice that range from the use of companion features of clicker remotes, seamless transitions, teachers' ability to stand at alternative points in the classroom, and even adoption of new software. I conclude this section of the literature review with what might seem unconventional. Erik Braun (2009) from the Department of Electrical Engineering, Technical University of Denmark, Lyngby, Denmark performed a teaching experiment that used digital photography to capture notes from a traditional blackboard. Braun's study consisted of 30-35 college students that attended approximately 20, forty-five minute lectures. The purpose of the study was to compare electronic text prepared presentations from PowerPoint to handwritten notes that were digitally photographed and placed onto the class website. Braun (2009) lists a variety of positive aspects of PowerPoint presentations first noted in a study by Apperson, Laws, & Scepanksy (2008) including: Presentations are easily provided to the students as electronic files, the teacher has the presentation

available as support to material during lecturing, and errors during the presentation can be almost completely avoided. However, Braun (2009) stated PowerPoint's shortcomings concerning students learning as researched by Henderson, (2007) and Winn (2003). These include: slides are commonly provided by the publishers of textbooks are mostly static slides with just text and figures, improvising and changing the order of the presentation on the fly in response to questions from students is not easy, and many teachers restrict themselves to just the simple slides rather than making an effort to prepare presentations with interactivity and dynamic elements (Braun, 2009). Braun (2009) indicates handwriting that is used on the basic blackboard is an alternative to PowerPoint and has a positive impact on learning. This correlation is attributed to controlled speed that is easier for students to follow, a process oriented presentation, teachers actively writing that gains the focus of the students, and ease of improvising and responding to non-planned questions (Braun, 2009). However, blackboard presentations are not readily available as student handouts, the blackboard space is usually limited, and complex figures cannot be included in a lecture based entirely on the instructor's drawing capability (Braun, 2009). Braun's study concludes that students indicated a preference for handwritten blackboard presentations over PowerPoint when digital photos are taken of the blackboard and posted to the class website as electronic handouts. Essentially, Braun has created a cost effective alternative to interactive whiteboard technology, a gadget that he endorses in the study but states that many higher education institutions lack the technology in their classrooms.

The college students in Braun's study indicated improved learning when the teacher wrote notes in front of the class rather than reading off of a general PowerPoint presentation. The improvement only occurred with the manipulation of the notes that were digitally photographed and distributed as electronic handouts. Braun's digital photography methodology is a makeshift model of the digital ink features of interactive whiteboards. Braun approves the use of interactive whiteboards in his study, as the technology provides the best of both PowerPoint and the blackboard. "The blackboard

is a very mature technology and it does not provide the same possibilities for multimedia integration as interactive whiteboards. However, the more advanced technology is not yet widespread in university lecture rooms" (Braun, 2009). Although Braun's study uses college students as a sample, I feel that the information gathered makes a clear argument for a change in teaching practice and tools in the classroom. Braun cites that students prefer and perform better when hand written notes are taken on the blackboard. However, this only holds true when students are provided copies of the notes taken on the blackboard. PowerPoint has served as a common method of providing handouts for students, however, Braun indicates that students do not pay attention to text and graphics that are previously embedded into presentations. Interactive whiteboards provide the best of both worlds. Features including digital ink, digital recorder, and the "save" feature allow notes to be taken in a similar fashion as a blackboard, but may be easily produced and provided electronic handouts that PowerPoint provides. Braun uses digital photography to create his own hybrid model that serves as a band-aid for an interactive whiteboard and mimics the learning needs of the students in his class.

Student Impact

Prior sections of the literature review have provided examples of teaching practice using interactive whiteboards. Penny Knight, Jennie Pennant, and Jennifer Piggott (2005) provide an extensive view of interactive whiteboards and student engagement in their test of the impact that interactive whiteboards have on teaching and student attitudes at Bracknell Forest primary. The study consisted of six teachers who had extensive experience using interactive whiteboards within their teaching practices and classroom methods. All six of the teachers agreed to participate, as they were concerned about helping children develop as confident, enthusiastic, and effective learners in mathematics (Knight, Pennant, & Piggott, 2005). Knight, Pennant, and Piggott's findings in the study were determined by

observations of students, student interviews, student questionnaires, and pre and post testing Knight, Pennant, & Piggott, 2005. Knight, Pennant, and Piggott's study found that interactive whiteboards increased student motivation and engagement, self esteem, and access to prior learning. Motivation was seen as students seemed to have an increased sense of eagerness to participate in class, which could be attributed to the teacher attitude or materials being presented (Knight, Pennant, & Piggott, 2005). Students interviewed stated their self-esteem and confidence during the learning process increased. The teachers who participated in the study accredit this increase to the visual support offered by the interactive whiteboards and software that provided ease to return to images as many times as needed, but also gave opportunities to use a range of images on demand (Knight, Pennant, & Piggott, 2005). Finally, interactive whiteboards gave the teachers and students the ability to access prior learning by returning to previous pages stored on the computer. This feature was a key contributor to student's overall learning (Knight, Pennant, & Piggott, 2005).

Knight, Pennant, and Piggott's qualitative study clearly states student support and excitement for the use of interactive whiteboards. This does not come as a surprise. Students within this study fall within Tapscott's N-gen category and would likely be naturally inclined to interactive whiteboards in the classroom. I would also state that students would support the disruptive change of interactive whiteboards that Christensen cites.

Mari Liles (2005) from the Texas School for the Deaf (TSD) published similar opinions on engaging students with the use of interactive whiteboards. Liles' provides personal testimonials that indicate increased excitement of students along with the ability to use the advanced visuals of interactive whiteboards to provide another method of delivering curriculum to students.

Liles' assessment of increased student attention and engagement is similar to what Knight, Pennant, and Piggott found. Liles' testimonial is interesting as it provided a testament to how students

with special needs may use interactive whiteboards as an alternative method of delivering curriculum. Understanding alternative multiple forms of delivering curriculum are essential to maintain the "wow" factor that is described by Beauchamp and Parkinson. Additionally, providing adaptations for students with special needs as described by Liles may translate into UDL teaching strategies.

A U.K. study provided more empirical evidence on the student impact of interactive whiteboards. In 2005, Kate Wall, Steve Higgins and Heather Smith at the Centre for Learning and Teaching at Newcastle University completed a comprehensive government sponsored evaluation into the use of interactive whiteboards with years 5 and 6 in English primary schools. Their study was originally designed to learn more about students' meta-cognitive process or method in which students think about their own thinking. For that reason, their study focuses heavily on student interviews and interaction with students. The interaction with students led to the discovery of students' support for interactive whiteboards and positive statements towards the technology. 80 students participated in the study (46 boys and 34 girls). The students were separated into groups of four to six and were asked to provide feedback, much like a focus group. Students wrote their comments down independently in addition to verbally stating them to the observers. In total the researchers collected 1,568 statements for analysis on this topic. The practice of students writing their own thoughts assisted the observers in better understanding their statements, ensuring their thoughts were being transcribed correctly. The results of the Wall, Higgins, and Smith study showed an in increase students' motivation, concentration, and attention. Pupils frequently mentioned how the interactive whiteboard assisted their understanding (n=40) (Wall, Higgins, & Smith, 2005). The data indicated a positive correlation between student performance and interactive whiteboards. Students also stated that interactive whiteboards affected their thinking (n=36) (Wall, Higgins, & Smith, 2005). Students also cited that the use of different software programs, visual display information, and games were all beneficial (Wall, Higgins, & Smith, 2005). The only negative revealed in the study stemmed from students' frustration with

technical difficulties with interactive whiteboards (Wall, Higgins, & Smith, 2005). Complaints were commonly grouped under the generic term: 'it breaks down.' Pupils from every school mentioned the fact that their board broke down (Wall, Higgins, & Smith, 2005).

Robyn Zevenbergen and Steve Lerman completed a study in 2008 that tests teaching pedagogy and student performance using interactive whiteboards. Similar to the Wall, Higgins, and Smith study, Zevenbergen and Lerman include quantitative analysis on student performance. The Zevenbergen and Lerman study consisted of a productive pedagogies framework to analyze classroom videos to explore the ways in which teachers use interactive whiteboards in mathematics classrooms. The data was collected using a purposive sampling technique in the selection of the schools. The schools were selected on their representativeness of the diversity found in Australian schools in terms of socio economic status, geographical location, technology implementations and school structure (single age classes, multi-age classes). Data was collected through classroom observations and video recordings. Zevenbergen and Lerman's study concluded changes in pedagogy as well as quantitative measures that evaluate student performance.

Pedagogical changes were identified in expedited lesson set up that resulted in quicker pacing of the lesson since the teachers were able to ask quick questions where there was little depth in the responses required. The research also indicated changes to student participation. Observers noted student excitement to be invited to the front of the class and to participate and manipulate objects and data on the interactive whiteboard as part of the lesson. These findings are aligned with the research of Beauchamp and Parkinson's "wow" factor. Additionally, Zevenbergen and Lerman stated a decrease in behavioral issues with the use of interactive whiteboards. This observation was consistent across the lessons and schools in the study and suggested that the technology helps engage students in the teacher's actions and the lesson.

Despite what could be interpreted as positive changes to teaching pedagogy, the study's quantitative analysis on student performance did not bode well for interactive whiteboards. In fact, the data in the study concludes that the use of interactive whiteboards with this specific study actually reduces the quality of mathematical learning opportunities. Additionally the data concludes fewer opportunities for connecting to the world beyond schools; and offers little autonomous independent learning opportunities for students. Zevenbergen and Lerman suggest that the use of interactive whiteboards in the study may not be providing opportunities for deep learning in mathematics classrooms.

Productive Pedagogy Analysis of IWB use in Upper Primary Classrooms

	ICT		IWB		
Dimension of Productive Pedagogy	M	SD	M	SD	*t*
Depth of knowledge	1.70	1.33	1.47	0.92	-0.62
Problem based curriculum	2.22	1.33	0.93	0.59	-3.60**
Meta language	1.70	1.05	1.33	0.62	-1.26
Background knowledge	1.80	1.13	1.60	0.63	-0.67
Knowledge integration	1.50	1.28	0.53	0.64	-2.81*
Connectedness to the world	1.39	1.41	0.73	1.03	-1.67
Exposition	1.13	1.59	0.73	0.80	-0.93
Narrative	0.37	0.93	0.20	0.41	-0.68
Description	2.33	1.04	1.40	0.63	-3.26**
Deep understanding	1.43	1.44	1.20	0.68	-0.61
Knowledge as problematic	1.15	1.44	1.13	0.74	-0.05
Substantive conversation	1.22	1.36	0.53	0.74	-1.85
Higher order thinking	1.30	1.52	1.20	0.77	-0.25
Academic engagement	2.22	1.33	1.47	0.83	-2.05*
Student direction	0.74	0.91	0.40	0.63	-1.34
Self regulation	3.26	1.12	2.2	1.32	-3.04**
Active citizenship	0.28	0.75	0.07	0.26	-1.09
Explicit criteria	2.83	1.22	1.27	0.96	-4.52***
Inclusivity	0.30	0.73	0.07	0.26	-1.24
Social support	2.48	1.21	1.27	0.59	-3.73***

Note. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 9. From "Learning Environments using Interactive Whiteboards: New Learning Spaces or Reproduction of Old Technologies," Zevenbergen, R. and Lerman, S., 2008, Mathematics Education Research Journal, 20 (18), p. 116.

Zevenbergen and Lerman (2008) indicate the reduced performance is a result of teachers using the interactive whiteboard as a "time saver" and not a teaching tool. Teachers in the study drew on resources that were made available by a databank of lessons rather than creating lessons of their own that would appeal to their students. These time saving tools were assumed to help teaching by reducing time spent on preparation of curriculum but also within the lesson. The prewritten lessons ultimately led to quicker paced instruction that was perceived to enhance learning by taking less time to draw representations on the board and allowing students to see more in less time. However, it is believed that the fast paced presentation that instruction with interactive whiteboards does not allow enough time for students to process the material, which is the rational for the lower student performance. Additionally, the use of prewritten lessons over teacher self-created lessons provide more opportunities for error, as the teacher may not have an in-depth or thorough understanding of the lesson.

Zevenbergen and Lerman's (2008) study reveals that despite the potential of interactive whiteboards, the ways in which they are used in the classroom may inhibit learning. However, they conclude that there is potential for interactive whiteboards to enhance learners' opportunities to experience mathematical representations and develop their mathematical thinking. Zevenbergen and Lerman recommend reorganizing pedagogy to foster interaction and collaboration in smaller groups, or to employ other tools alongside interactive whiteboards to encourage interaction and retention among learners.

The research completed by Zevenbergen and Lerman (2008) is a reminder that teachers educate students, not computers and the internet. Interactive whiteboards have amazing potential as stated by all researchers included in the literature review. However, it is important and vital to student success that teachers not use the technology as a method to cut corners on preparation. Rather, teachers need

to understand the potential of interactive whiteboards to be used as an educational tool that supplements their teaching.

Hannah Slay, Ingrid Sieborger, and Cheryl Hodgkinson-Williams researched interactive whiteboards and their use in South African schools in 2007. Their paper is a case study on three government schools and highlights the reaction of teachers and students to the use of interactive whiteboards. All three schools were located in the Grahamstown area for their proximity to the Rhodes University where the research team was based. These schools were chosen for their necessity of suitable ICT facilities, internet connectivity, teachers with knowledge of ICT's, and supportive administration. Participants in the study received a laptop computer, projector, and eBeam Interactive Pen System (interactive whiteboard). The teachers also completed four, two-hour training sessions to learn about the technology they just received. The research consisted of an introduction interview that followed the training sessions, three in-class teacher observations, and an end of research interview. Ten students from each teacher were also invited to participate in the end of research interviews to provide a student perspective to the study. The research findings contained both positive statements as well as negative. The most common response from the participants was their preference for the "big screen" display. However, the researchers attribute the big screen display to the projector and not the interactive whiteboard. In fact, three out of five teachers indicated that they would prefer the laptop with the projector over the use of the interactive whiteboard. However, there were a variety of positive statements specific to the interactive whiteboard. The majority of the study sample favored its ability to incorporate multimedia content into the teaching environment. Teachers also indicated great value in using "up-to-date technology." Most teachers involved in the study pointed out that their learners were attracted to the eBeam indicating support for the technology. The biggest criticism of interactive whiteboards echoes the research of Zvenbergen and Lerman, as teachers overwhelmingly thought that teachers did not use Improving Classroom Teaching (ICT) practices with the interactive whiteboard.

Teachers in the study went on to state that "...teachers who already lack ICT skills result in poor use of the technology" (p.1333). The teacher's statement may be perceived as overall poor teacher training, or lack of support for interactive whiteboards. The qualitative study fails to define their intention.

The study shares similar viewpoints as the research of Zvenbergen and Lerman. Although the study provides both positive and negative insight on interactive whiteboards, I feel the research may have some limitations. The teachers in the study did receive interactive whiteboard training, however research on the "technology transplant" (Slay et al 2007; Tedre, 2006) suggests that teachers need time to engage with the new technology to find ways that it can be used to suit their specific purposes and technology needs (Slay et al, 2007). The study did not allow teachers to have the additional time to become acquainted with the technology, which may have impacted the study. The researchers also stated the evaluation of the qualitative data in a consistent manner as a problem they encountered when completing the study. Their disclosure of this issue indicates another possible shortfall in the study.

Conclusion

Interactive whiteboards are the latest buzz technology in education. Evaluating their success and full impact through quantitative measures of student performance is seemingly difficult. However, the literature found on interactive whiteboards indicates that the technology has had an impact on teaching practice and student engagement.

As interactive whiteboard technology use continues to grow, it is likely that more studies will surface on this topic. In continuing my research on interactive whiteboards, I performed a qualitative case study on interactive whiteboards. The case study is in the following section of the paper and

includes my interpretation of interactive whiteboards and their impact on teachers, teaching practice, and students.

Case Study

Purpose of Study

A qualitative case study on interactive whiteboards was performed at a Saint Paul, MN suburban high school as part of my leadership application project (LAP). The purpose of this study is to examine how their high school successfully implemented interactive whiteboard technology and if its features have an impact on teachers, teachers' teaching, and students' learning. The examples listed in the case study are exclusive to the high school in the study and may not remain consistent or relevant to other schools or educators. Information in this study was gathered through a series of interviews, classroom observations, and interactive whiteboard and technology demonstrations. It is my hope that readers of the case study will find value from the data collected and ultimately use the data to expand their interest in and ideas of how to use the technology.

The School

The school high school in the study received high ranks from peers in the field of education and is currently viewed as a model example that others in the field of education can use as a benchmark for learning. This high school was chosen by design to provide ideas for best practices and successful implementation of interactive whiteboards. It is my hope that in researching their successful implementation of interactive whiteboards on a school-wide basis will provide expertise that readers of this case study will benefit from.

The high school educates grades 9 – 12 with an estimated student population of 1,016. Based on standardized test scores the state has awarded the school a five-star rating, the highest level that can be achieved. The school was recognized by Newsweek magazine in April 2008 when it was included in

the list of 1,300 *Top High Schools in America* where they were in the top 2/3rds of the study. The school continues to achieve Adequate Yearly Progress (AYP) in compliance with the No Child Left Behind (NCLB) standards. A recent census indicates the school demographic of 94% Caucasian, 2% Black, 2% Asian and less than 1% Native American. The same report states that only 6% of students qualify for free or reduced lunch. In 2006 – 2007, the high school had 513 students in advanced placement classes, which is roughly half their student body. About 90% of students continue on to college after graduation, and the high school's dropout rate is 1%.

	Average ACT Score	Average GPA	Graduation Rate
Case Study High School	24.4	3.1	99%
Minnesota Average	22.3	2.8	92%
United States Average	21.3	N/A	70%

The chart lists academic achievements that compare the high school from this case study compared to the averages of the state of Minnesota and the nation as a whole (2006-2007 school year).

Study Participants

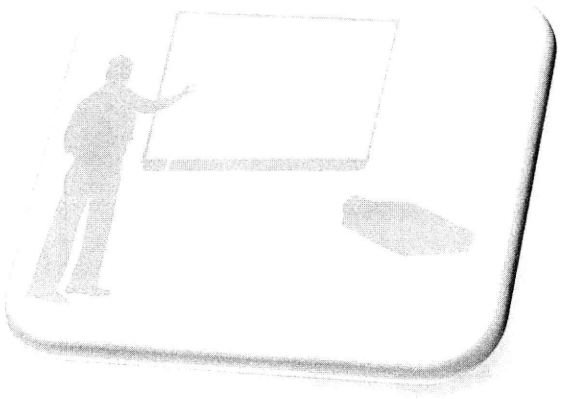
The study sample included: a science teacher at the high school, a teacher from another school in the district who performs interactive whiteboard trainings, an administrator from the high school, and the school district's technology specialist. The participants in the study were all volunteers that received high recommendations from their peers as "experts" in interactive whiteboard technology. These participants were specifically chosen to provide an in-depth view of interactive whiteboards and share ideas on how the technology may be used to its full potential. In an effort to preserve the identity of the participants in the study, pseudonyms will be used and the proper school name will not be listed. In the case study, I refer to the Administrator and Technology Specialist as their titles. The teachers have been provided alternative names to signify which teacher is included in the statement. The science teacher is

referred to as "Teacher Jack" while the second teacher/ interactive whiteboard trainer is listed as "Teacher Jane."

The school in the study is widely recognized as being advanced in science, technology, engineering, and math (STEM) education. The Administrator has worked tirelessly to develop technology and engineering programs within the school that are now recognized as an example and best practices for other learning communities. The Administrator's work was recognized during the 2007 – 2008 school year when she was awarded the Assistant Principal of the Year Award. Teacher Jack has also been recognized for teaching excellence. He received a national teaching honor that was awarded by Vice President Cheney in Washington DC. Teacher Jack's experience with interactive whiteboards began when he participated as a select teacher for an interactive whiteboard pilot program at his previous school. Following his experience with the pilot program Teacher Jack joined the high school in the study and has participated with their interactive whiteboard program since day one. The Technology Specialist has experience in implementing interactive whiteboard technology in the high school in the study along with all other schools in the district. The Technology Specialist has also shared his interactive whiteboard expertise by providing trainings for the schools in the district and at local education conferences for outside districts. Teacher Jane's expertise started with the district's implementation of interactive whiteboard, as she was one of the initial teachers that participated in the 2005 pilot program. She has now transitioned to spend less time in the classroom and more time providing teacher training and professional learning communities. Similar to the Technology Specialist, Teacher Jane is a regular face for teacher trainings outside of the district.

Interactive Whiteboard Costs and Features

Interactive whiteboards are filled with features that liven up presentations and make learning more exciting. The technology was first designed in 1991 (www.smarttech.com) and is seen in businesses, schools, and even mass media news coverage.



Interactive whiteboards are basically large interactive computer screens. General set up for the technology requires three major hardware components: computer, computer projector, and an interactive whiteboard. The computer is the central point and uses the projector that is either free standing or mounted in the ceiling or wall to display images from the computer screen onto the interactive whiteboard that acts as a touch screen and sends signals back to the computer.

A common question with technology is, "what is the life-cycle?" The Technology Specialist stated "the interactive whiteboards themselves do not have a shelf life." The projectors and computers are a different story. Many organizations run a three to five year life cycle on computers. The Technology Director indicated that the total life cycle of a projector is ten years. However, projector bulbs have a lifespan of 2,000 hours which translates to a two to three year span in their classrooms. These bulbs are a $250 repair and can easily "Nickel and Dime" a school if these replacements are not

appropriated into the budget. The good news is that the audio and visual connections for interactive whiteboards are standard and will accommodate and adapt to changes and upgrades in computer and projector technology.

Outside of the interactive whiteboard hardware, there are software needs. The school uses SMART Notebook as the primary software for the technology. SMART Notebook is a free download for students and teachers at www.smarttech.com and also provides free updates for earlier software versions. Participants in the case study stated that it is relatively easy to import material into SMART Notebook. The software converts Microsoft files, so implementing files that you already had in Word or PowerPoint is an extremely easy task. The teachers stated that building lessons in SMART Notebook is a similar interface to using PowerPoint. Both teachers agreed, that the initial set up of uploading images and text from lessons built outside of SMART Notebook is a daunting task. However, they are easy to update and share after the tedious work of uploading previous lessons is completed. One teacher stated, "The ease after the time consuming set-up makes it worth the effort."

Implementation of Interactive Whiteboards

The Saint Paul, MN suburban school began its implementation of interactive whiteboards in January 2006. The technology was implemented in three waves that distributed the technology by department. Implementing the technology by department encouraged teachers to build "SMART circles and networks," a title that was inspired by the SMART Technology brand of interactive whiteboards to communicate, collaborate, and share lesson ideas using the new technology. The networking circles around technology were an immediate change and had an impact on teacher's teaching, as some teachers collaboratively built lessons together for the first time.

The initiative for interactive whiteboards in every class of the high school was part of a district wide campaign that was championed by the School's Superintendent and Assistant Superintendent. The movement for interactive whiteboards grew from a technology pilot program at an elementary school in the district that included interactive whiteboards. Teachers with interactive whiteboards at the elementary school held workshops and community nights to show off the districts investment. This ultimately led to a groundswell of support to include the technology in all schools and classrooms in the district. The elementary school's pilot implementation was a success and left the community, district faculty, parents, school foundation, and school board thirsting for the technology in all schools in the district. This support was reaffirmed when the school board unanimously approved on the first vote inclusion of interactive whiteboards in every classroom. Following the approval of the school board, interactive whiteboards were implemented on a school-by-school basis across the district. Within each school, the technology was implemented in manageable stages organized by grade level in elementary schools and by subject or department in secondary schools. The organized installation process was designed to create peer-to-peer sharing within grade levels and departments and use the technology as a method of teambuilding. The school district's Technology Specialist estimated costs of roughly $3,000 per classroom initially. The movement was heavily funded by the district's foundation that provided grants as a cost reduction for the new technology. The school district also received funding from personal contributions from passionate parents who believed that their child's learning would be enhanced using interactive whiteboard technology. Teachers within the district also stated that the schools shifted the focus of funding to allow for interactive whiteboards, which meant that the procurement of other school materials and updates were placed on hold. The teachers in the study praised funding interactive whiteboards as a priority, as it has improved their classrooms immensely.

The transition to interactive whiteboards has had a major impact on the school. The school's Administrator who participated in the study stated "Teachers would be very disappointed if the

technology was ever removed from their classroom." The Administrator also stated that students have taken an interest in the technology and faculty would likely hear complaints from students if the school ever removed the interactive whiteboards from the classroom. Luckily, the implementation has been widely accepted and seems to be here to stay. The new technology in the classroom is visible. Interactive whiteboards hang in the front of every class. The school divested themselves of their overhead projectors. The new interactive whiteboards have projecting capabilities and make the primeval overhead projectors a redundant feature in the classroom. These and other unused items were sold at a district wide garage sale that helped raise funds for the school. However, I did find one overheard projector stashed in the corner of a room. It's not being saved for antiques road show; rather the science teacher used the classic overhead projector when teaching lessons on light projection and describes the overhead as a "very powerful flashlight." The alternative use of the overhead is the only action it has seen since the implementation of interactive whiteboards and is likely the only overhead projector remaining in the building.

Another bonus of the interactive whiteboards is that with their multiple features they can take the place of various pieces of equipment formerly found in the classroom. Televisions are in many ways another redundant technology when compared to the features of interactive whiteboards. At the high school, there were still televisions mounted in the corners of many classrooms. However, most teachers have made the shift from using the television in the corner of the room to using the interactive whiteboard to play DVD's and VCR videos. The general rationale for playing videos on the interactive whiteboard were the simple facts of larger screen, enhanced picture and sound, and its center mounted proximity which provides a better vantage point for students compared to the corner mounted television. To understand and use all features of interactive whiteboards requires training. Luckily, the school in the study heavily invested in training programs. In fact, their efforts can be used as a model for other schools.

Interactive Whiteboard Training

As part of the implementation of the technology, teachers were required to complete training to learn how to use all properties of the technology. Since teachers command interactive whiteboards, in principle the technology will only function as far as the teacher's knowledge and comfort level. Teachers who are unaware of the features of interactive whiteboards will never be able to use the technology to its full capability. Therefore, teachers using the technology must be trained on interactive whiteboards to ensure that it assists their teaching and doesn't prohibit it.

The high school in the study recognized that in order to receive a full return on their investment, they needed to train every teacher on interactive whiteboards. As part of the implementation in 2006, teachers received 20 hours of technology training on interactive whiteboards. These hours were required by the school and counted as staff development credits and teachers were paid for training hours outside of their contract. The school has maintained its commitment to training teachers. All new hires are required to receive the same training that was given as part of the implementation of interactive whiteboards. The entire teaching staff receives ongoing training as well. The Administrator in the study indicated that teachers complete a minimum of ten hours of "technology staff development a year." Interactive whiteboards have also been included in the criteria of staff observations. The Administrator in the study shared that meetings are held with each teacher to find out how they plan to incorporate interactive whiteboards into their lessons. More importantly, "how are you going to use your SMART [interactive whiteboard] differently than a large screen television?" Teachers at the high school are required to include this in lesson plans that are later reviewed by administration.

Interactive Whiteboard Training Models

Initially, the school in the study had two types of training. The first was a summer session that paid teachers to attend an eight-hour mass training on interactive whiteboards. Since the school was an early adopter of interactive whiteboard technology in K-12 education, there were limited training programs designed for educators. Seeing limited options, the Technology Specialist attended SMART Technologies trainings, which turned out to be a wise decision for two major reasons. First, sending one representative from the school was more cost efficient than sending each member of the teaching faculty to the SMART training at a price of $150 a head. Second, considering their early adoption, even SMART Technologies did not have trainings targeted to educators. Rather, the Technology Specialist took the concepts and knowledge of the features that he learned at the SMART Technology training and geared the business applications to reflect how teachers will use the technology in the classroom. Using the newly created applications and examples for the education field, the Technology Specialist presented an initial mass training for the teachers that largely mirrored the SMART Technology presentation and curriculum. The training provided examples and demonstrations of every feature of the interactive whiteboard and encouraged teachers to explore and create lessons using the new features. Follow up trainings were provided to answer ongoing questions after the mass brain dump they had just received.

The second training in the initial model consisted of monthly two-hour follow up sessions. These trainings began at the beginning of the school year and were designed to answer any questions that the teachers had encountered in creating lessons on SMART Notebook software over the prior month. The school administration and Technology Specialist quickly learned that they had "over planned" the amount of training needed. Teachers were learning faster and running further with the technology than anticipated. Much of this was credited to the excitement of the staff to have the new

technology and the peer to peer sharing that occurred with the implementation of the interactive whiteboards. As a result, the school eliminated the mandatory trainings in favor of "SMART Slam" after school networking sessions.

SMART Slams were held after school once a month. Since teachers quickly learned all of the interactive whiteboard features these sessions were voluntary. Rather than focus on interactive whiteboard features, teachers group together by grade level or subject matter to share how they used the interactive whiteboard and the lessons they had created over the last month. Teachers stated that grouping these sessions by department helped build support and adoption of interactive whiteboards by all teachers. "No longer were the tech savvy people and the tech learners separated, everyone was learning and sharing together," exclaimed Teacher Jane. Although the sessions were informal, they still had a strong level of support and organization from the school's administration and the district technology leaders. Over the course of the month, school administration and the district's technology department observed classes to see how teachers were using interactive whiteboards. Technology leaders created discussion topics and outlines that assisted the conversation in the voluntary networking and sharing sessions. The continual communication of the SMART Slams encouraged teachers to share lesson ideas, practices, favorite features, and even written lessons through their schools shared drive. The SMART Slam sessions ended in fall of 2008, but continued networking and sharing of lessons is still prevalent within the school. Peer sharing has also produced a more consistent presentation of school curriculum. Prior to interactive whiteboards, teachers who taught the same class did not always teach the same material or concepts.

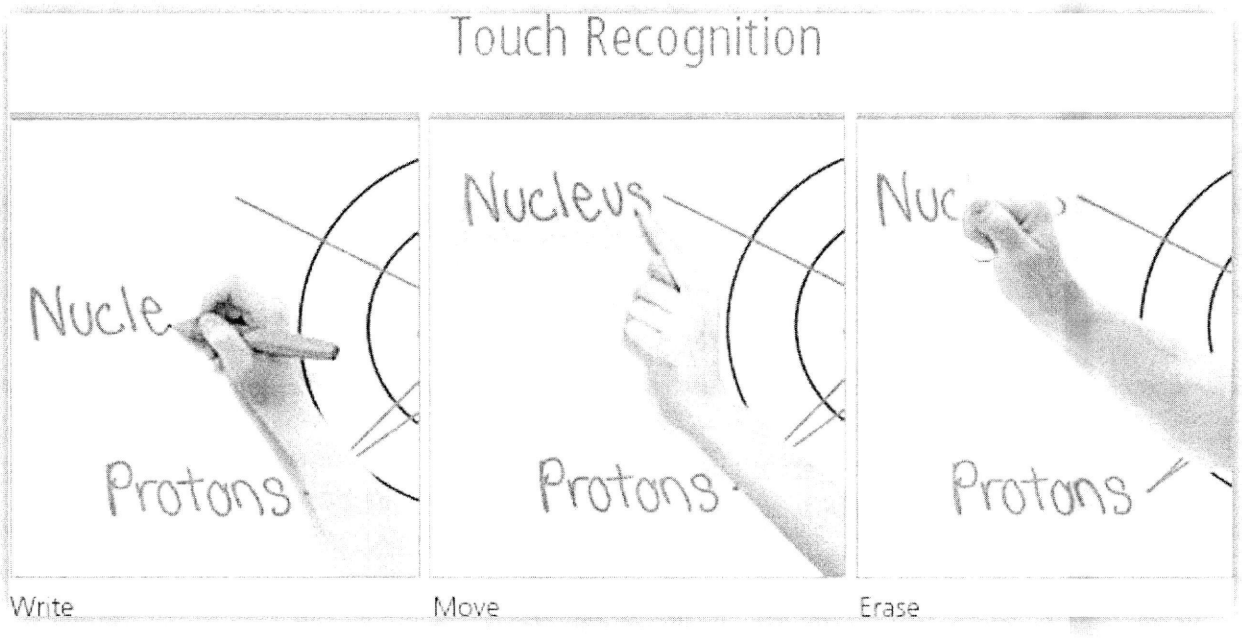
Interactive whiteboard training stretches beyond faculty teachers. In fact, you'll find school administration at nearly all technology trainings along with substitute teachers. The school encourages substitute teachers to receive the same training on the technology as their contract educators.

Including substitutes not only provides them an outstanding opportunity to learn about new technology in the classroom, it also eases the transitions between substitute and contracted teacher when necessary. Nearly all of the teachers create their lessons and lesson plans in SMART Notebook, software that is specifically designed for interactive whiteboards. Training substitutes on the technology allows the students to learn the same lesson the teacher had planned for the day and presented using the same techniques as the teacher envisioned. The process is also easier for the teacher as they do not have to rewrite or change the lesson plan to an archaic version from what they had already prepared using advanced technology. The school also has a separate log-in and shared drive for substitute teachers. This feature protects the security of the contract teacher and also allows them to send information to the substitute teachers' shared folder if there are any last minute changes to the lesson, or if the substitute request is unexpectedly extended.

The Technology Specialist maintains the district's competitive edge by continuing to network with providers of interactive whiteboards including SMART Technologies and local distributer Tierney Brothers in Minneapolis, MN. In doing so, the school is able to keep up to date with new features, additions, and software updates. The District's Technology Specialist and Teacher Jane are frequent adjunct trainers for technology at education conferences around the state and for K-12 education cooperatives, including TIES located in Falcon Heights, MN. The school also holds open houses and continues to share their success with implementation and training with a number of neighboring communities. However, it is important to note that participants in this study accredit their success to district and school wide implementation of the technology. Schools that implement interactive whiteboards that are limited to a select group are likely to lack the peer to peer networking that is believed to be a major contributor to the successful implementation and teacher know how.

Teachers' Use of Interactive Whiteboard Features

Everyday Features. What do teachers do with these massive computer screens and SMART Notebook software? Three key features of the interactive whiteboard are the touch system, digital ink, and the save function (SMART Technologies). The touch system allows teachers to write, erase, and perform mouse functions with their finger. You do not need any proprietary tools to exercise the touch system features. It was described as a common "everyday" feature by the two teachers in the study. Using the touch system, teachers can easily manipulate objects on the screen by making them larger or smaller, copying images and replicating them for additional examples, even dragging objects and text to various parts of the screen. Teacher Jack stated, "In dragging images and text, the object that is moved becomes its own entity, which makes the whiteboard different than any other teaching tool." Teacher Jane stated, "Having the ability to manipulate specific objects has changed the way they [teachers] teach and allows them [teachers] to present the material in alternative ways to gain students' understanding." At the school, the touch feature is the most common feature that is used on the interactive whiteboard and the teacher comments are a statement about its importance and success.



(Image found on www.smarttech.com)

Digital ink is a SMART Technologies term, however this feature is available from various brands of interactive whiteboards. Using a stylus that is shaped like a standard whiteboard marker, teachers may write on the interactive whiteboard screen and digital lines are created in the stylus' path. Teachers may use this feature to draw shapes or text on the screen. Digital ink may be drawn over images, websites, and even videos. Different color styluses are available, allowing teachers to write in a variety of colors. The interactive whiteboard touch screen also recognizes movements of a white board eraser that removes the digital text when it is applied to the screen. Teachers in the study stated that digital ink is another "everyday" interactive whiteboard feature.

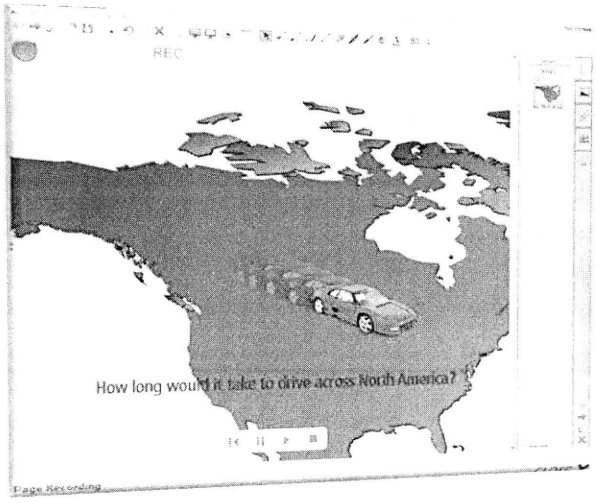
Finally, the save feature is another "everyday" application. Using the save function, teachers can capture their work on the interactive whiteboard as a screen shot that is saved directly to their computer and may be edited, exported into other formats, and even posted on classroom websites or emailed to students. Teacher Jack exclaimed, "The ability to email students lessons is amazing and how I typically communicate with students that have missed class." Another great benefit of the save

feature is the ability to use the same material and save each class period's progress separately and with notes specific to their class period under different file names (Nolan, 2009). This feature makes it easier for teachers to maintain post lesson follow up when they teach back-to-back classes (Nolan, 2009).

"Wow" Factor Features. The teachers in the study stated that although the touch system, digital ink, and save features are fantastic and have changed the way they conduct their class, those functions have become everyday-ordinary tools to students. In order to continually "wow" students, the teachers are forced to push the envelope of the interactive whiteboard capabilities and use new and cool programs to maintain students' excitement. Three wow functions are SMART Recorder, Magic Pen, and Clickers. SMART Recorder and Magic Pen are created through SMART Notebook Software; Clickers are interactive remote controls that are an interactive whiteboard accessory, but still compatible with its software. The teachers enjoy using these three additions to excite and engage students; however they are not necessarily included in day-to-day lesson plans.

SMART Recorder is another free software download at www.smarttech.com and allows teachers to record their entire lesson in advance of classroom teaching or during. The lessons may be replayed for other class periods, shared with peers to be implemented into their lesson plans, and posted to websites for students that may have missed the lesson or are looking for additional review. "SMART Recorder is a student favorite" exclaimed Teacher Jane who went on to say that "the students' world is visual, using animation and other visual features peaks their interest." SMART Recorder also allows teachers to prepare their lesson in advance and circulate the room or stand to the side while the lesson plays as a video on the interactive whiteboard screen. In doing so, teachers are not standing in front of the board blocking the view of half of the class while they write or present. Teachers also have the ability to focus on students while the material is being presented. No longer are they focused on writing

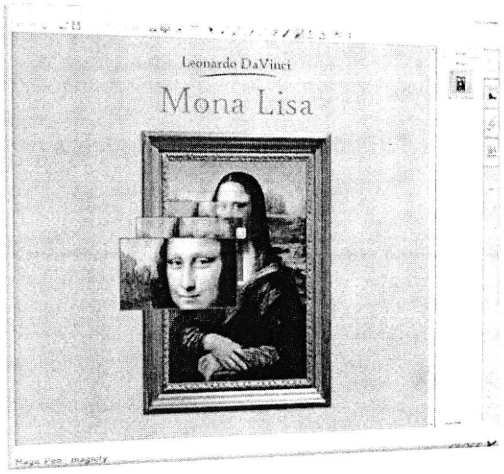
and changing presentation slides. The SMART Recorder playback automatically advances the material similar to a DVD that allows the teacher to control the pace by pausing or stopping the video at any time to field questions or provide further clarity on topics. These on screen demonstrations created by the teacher enable them to better engage with students during the learning process.

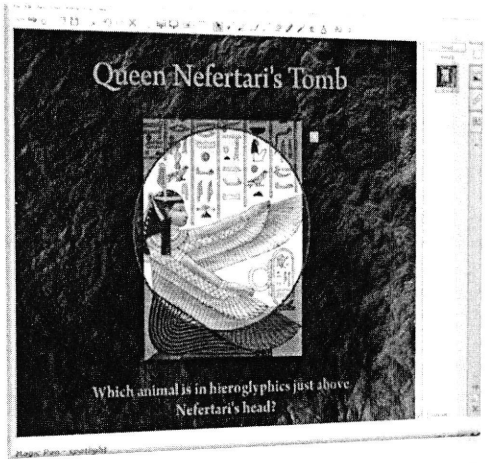


(Image found on www.smarttech.com)

Magic Pen is a feature of SMART Notebook software and another way to keep students on their toes. Using the three in one feature, teachers highlight specific material in the lesson by magnifying objects, spotlighting material, or writing text that fades away in seconds. To use the magnify feature, teachers simply draw a box around any image in their presentation. Doing so enlarges the box and teachers may also adjust magnification levels. The spotlight feature is commanded by drawing a circle around the area to be highlighted. When in use, the spotlight feature grays out the other items on the screen causing the students to naturally focus on the highlighted area. The spotlight may be enlarged

and moved similar to the magnify feature. Finally the fading text allows teachers to quickly write text over websites and presentations that do not need to be erased. The text is programmed to fade away after ten seconds, which allows the presentation to continue without being permanently altered. Although a teacher in the study has used the disappearing text feature, he lightheartedly commented, that "It'd be a great way to see if students are paying attention and how many would notice that the text disappeared if they didn't take notes fast enough." However the teacher decides to use the three in one features, it is clearly a dynamic tool that has provided new presentation methods for teachers.





(Images found on www.smarttech.com)

Interactive whiteboards are compatible with a variety of accessories that provide additional features to the technology. A popular example is handheld response systems that are commonly referred to as "clickers." Clickers are wireless remote controls that are given to students to use during class. Using clickers, teachers can create multiple-choice questions that ask for student responses throughout class. With the click of a button, teachers are able to immediately assess students understanding of the topics being presented and decide if it is appropriate to move to the next topic of a

lesson or if specific elements need to be reviewed or better clarified. Each remote has a specific ID so teachers may monitor each student's performance. Clickers are also equipped with a "question button." Students may use this feature at any point to virtually raise their hand to indicate that they have a question. The virtual hand raises are recorded in SMART Notebook software. Teachers can use the collection of this data to analyze lessons and common points where students had questions. The virtual hand raises also send an instant message to the teacher's computer to alert the teacher during independent or quiet working time. This element of clickers provides fewer disruptions during independent or quiet working time.

Image of Clicker Remote

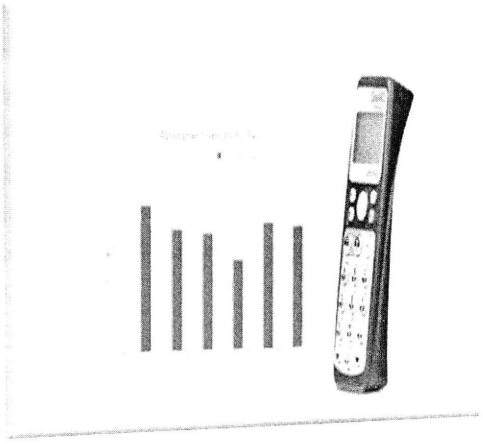
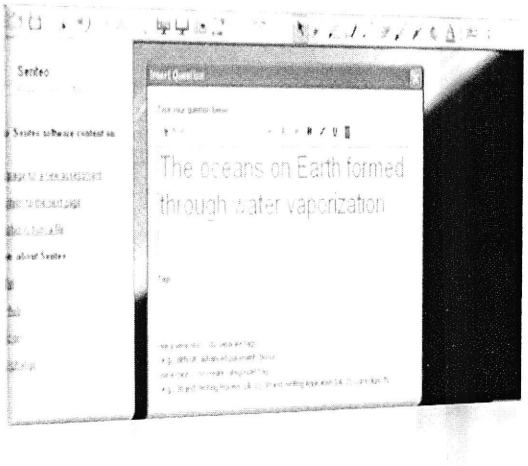


Image of Question Set-up on SMART Notebook

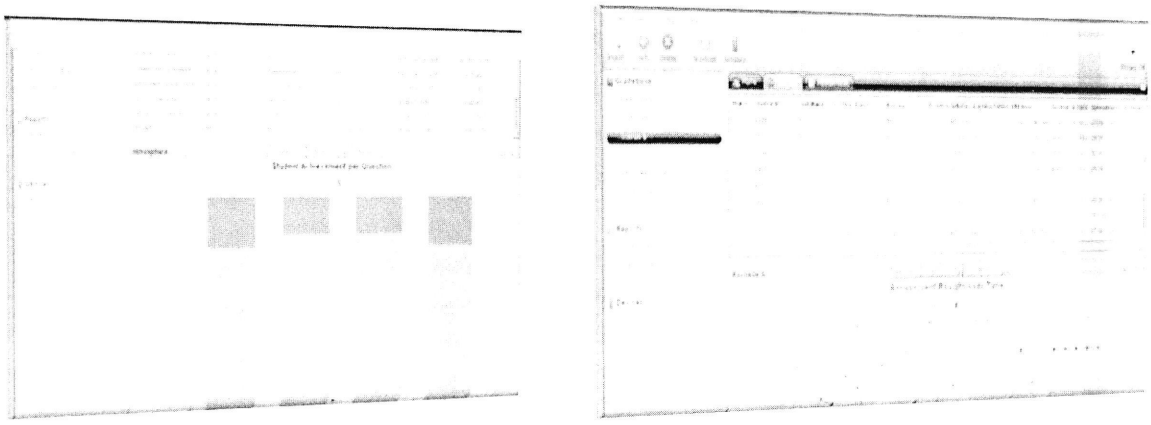


(Images found on www.smarttech.com)

The teachers in the study provided great testimonials for clickers, however they both clearly stated that additional prep time is needed to set up this feature. Each response for students must be entered into SMART Notebook in advance so the technology may decode the answers. Teacher Jane stated that some of her peers will use clickers as a "glorified scan test" by asking students to use clickers to enter responses to test questions rather than grading them on paper. Examples like this are one way

to confuse the ease of immediate response with the full potential of these tools. The same teacher stated the true potential of clickers is its ability to aggregate the data. SMART Notebook will graph student responses so the teacher may see specifically who and how many students had similar responses to questions during lessons and tests. Student names may also be included on graphs to identify any possible trends and the teacher may follow up with specific students if needed. Teachers may also identify how much time was spent on each question and when the students asked for teacher help during the lesson. Using the tool to its full potential will change teaching practice by providing immediate feedback to the teacher and assist in helping them to redevelop their lessons as needed. Teacher Jane's comment indicates that not all teachers understand how aggregated data can assist their teaching practice. Understanding that concept, teacher training should be modified to include examples to reflect the potential uses of data mentioned by teacher Jane.

Images of Data Graphs Using Clickers



(Images found on www.smarttech.com)

The demonstrations of both the everyday features and wow features provided by the teachers in the study were intriguing. In continuing the research of this fascinating topic, teacher observations

were performed within teacher Jack's classroom to see how he specifically uses the technology and these features to engage students in the learning process.

Science Classroom Observations

Teacher Jack shared that the interactive whiteboard is an everyday tool. All lessons are built in SMART Notebook. He describes the process of creating presentations similar to a Microsoft PowerPoint template that is user-friendly for all levels of technology users. Teacher Jack admits that some lessons do not use the entire interactive whiteboard feature. However, he makes a constant effort to build a variety of components of the technology into his lesson plans. SMART Notebook is more advanced than PowerPoint. Teacher Jack mentioned the digital ink feature that allows teachers to handwrite on top of images and typed text, a feature that he strongly advocates. "Using embedded text doesn't always grab the attention of the student. Letting the class work through the problem and capturing their thoughts in handwritten notes on top of the lesson engages the student in the learning process" stated Teacher Jack. Using SMART Notebook, Teacher Jack is able to prepare lessons in advance, but manipulate them with handwriting text and simply rearrange images using the touch screen. These features combine the benefits of a PowerPoint presentation with those of a general blackboard, a hybrid model that Professor Braun (2009) of Denmark advocates.

In class, he uses a variety of colors, which was simply stated as, "I have the color options, why not use them." Always a fan of color, Teacher Jack tries to incorporate colors when handwriting that will align with the students' intuition. Yellow is used to represent light rays, blue for water, and green for grass. The color options are vast and while the he hopes that students will use color in their notes, it is not required. Rather the battle still remains of students bringing writing utensils to class at all. SMART Notebook allows whatever the teacher or student writes on the interactive whiteboard to be saved

directly to the teacher's computer. Once saved to the computer, the updated presentation may be easily posted to the internet, school web portals, printed for notes, and saved for future lesson planning, or even emailed to students and parents.

Adding handwritten notes to presentations is a great feature, but only scratches the surface of the interactive whiteboard's capabilities. Teacher Jack uses a variety of animation and click and drag features as part of classroom lessons. "Having the ability to manipulate the materials with the [interactive whiteboard] SMART board is the key feature" Teacher Jack added that the "greatest challenge is using the technology to present the material in a variety of different ways." He demonstrated a physics lesson on reflective light. By using three images of mirrors the teacher arranges one graphic with a light ray that is directly hitting the mirror, which reflects the light directly back to the source. The other two mirrors are set up as opposite 45-degree angles. The teacher uses arrow graphics to display the path of the light ray towards the mirror and an additional arrow that depicts its reflection. This portion of the lesson and technology is rather elementary. The true use of the interactive technology is seen when Teacher Jack moves the images with the touch of a finger and placed the three mirrors into concave and convex shapes. Simply manipulating the graphics visually depicts an entirely new lesson in a second's time. Teacher Jack uses the term manipulation vs. animation, as the interactive whiteboard "provides more than fly-in animation of PowerPoint." Images and graphics may be physically moved and dragged to any portion of the screen multiple times. Teachers make these motions in real time without any additional set up, which is different than prior technologies. Teacher Jack continually thinks ahead to incorporate new and upcoming lesson ideas and tries to anticipate students' questions and uses manipulation similar to the light reflection lesson to provide visual answers for students in advance of their asking.

As you can imagine, using the interactive whiteboard for classroom lessons takes preparation. Teacher Jack stated that it takes about the same amount of time and effort to create lessons using the interactive whiteboard than before. Teacher Jack shared his opinion that like anything else, there are both pros and cons. One negative is the mass amount of initial data implementation that can be a time consuming project. However on the positive side, once the data and images are imported, it is much easier to electronically search for files than search through binders of transparencies. Another positive is the ability to make immediate changes to lessons. Using the interactive whiteboard, a teacher can easily move or manipulate objects. In doing so, teachers can instantly change graphics, whereas with the overhead transparencies it would take recreating the file and running to the copy machine. Overall, once you get past the initial set up, it is easier to create, change, store, and search for lessons on the interactive whiteboard.

Conclusions and Recommendations

Interactive Whiteboard Technology Can Change the Classroom

The high school in this case is one of outstanding merit. It has been nationally recognized for their students' accomplishments. Additionally, it is home to an outstanding faculty that includes teachers and administrators who have been recognized for their excellence statewide and even across the country. The clear and simple lesson learned from the teacher observations and interviews is that interactive whiteboards have changed the teaching practice of the two teachers involved in the case study. Teacher Jack stated, "Returning to a classroom without an interactive whiteboard would not be his first choice." He even offered an amusing story of giving a presentation on a basic whiteboard in front of peers during which he attempted to use interactive whiteboard commands. The natural tendency indicates the teacher's familiarity with the technology and desire to use it. Teacher Jane made a stronger statement "that she cannot even fathom returning to a classroom without a SMART Board!"

The color, technology, and animation, it's the students world. Teacher Jane has enjoyed implementing new technology with the students and believes it has had an impact on learning. "A picture says 1,000 words." She believes that the use of visual aids in the classroom has had a clear impact on the classroom.

Interactive Whiteboard Technology Can Impact Teacher Collaboration

Technology users and experts have long been stereotyped as quiet introverted people. Similar stereotypes view computers as barriers to communication. The high school in the case study defies those typecast labels with the first and most clearly seen change to teachers and their teaching practices. Prior to interactive whiteboards, the teachers in the school were social, but not social about sharing lessons and how they use gadgets to excite students. The SMART Circles and SMART Slams are two examples of peer to peer networking that have occurred as a result of implementing new technology. Teachers within the school are now eager to share ideas on how to use interactive whiteboard features, graphics, games, and lessons. The new technology appears to have provided a platform for new discussion and sharing that did not always occur before.

The interactive whiteboards have also transformed teacher presentations. Both teachers in the study made clear statements about the amount of work involved with the initial set-up. However, it seems that there is benefit and reward to the tedious preliminary preparation. Teachers in the high school may change the direction of their lesson on a dime. Manipulation of graphics to answer alternative questions, connecting to the internet and displaying what is found on the web in front of the entire class, Magic Pen features and more have all provided teachers with presentation options that never existed before. Interactive whiteboards have also changed the manner in which teachers present

curriculum. As Teacher Jane stated, a picture says 1,000 words. Students are visually oriented and more excited about the technology than textbooks.

Teacher Training Key Component for Success

Teacher training is important and a major influence on the success of the interactive whiteboard technology at the high school. Both teachers in the study feel that their school and school district have provided outstanding training programs and continue to stay up to date with new and recent trends in the technology. Teacher Jane indicated that she has performed a lot of independent exploration and really worked to personalize the technology to her classroom and students. Helpful websites, including Teacher Tube (www.teachertube.com) and SMART Technologies website (www.smarttech.com), provide training materials and short tutorial videos specific to using interactive whiteboards in the education field.

The high school's commitment to training substitute teachers is forward thinking. They are training the future fulltime faculty members on interactive technology and transforming teacher preparation for substitute teachers. Often times substitute teachers are given videos or alternate lessons that stray from the teachers' intended planning for that specific day. Training substitutes on interactive whiteboards, allows students to receive the same lesson as originally planned. Providing subs with training and access to a shared drive where materials and lesson plans are stored has transformed the way that teachers prepare when they need to be away from the class.

Changes to Teacher Preparation

Interactive whiteboards have changed teacher preparation. Both teachers made it extremely clear that the initial set up and transfer of prior lesson plans to SMART Notebook and interactive whiteboards is labor intensive! However, both agreed that after the initial set-up, lesson prep has become less tedious. Lesson plans have become collective among teachers through the school's shared drive. Images, graphics and text are easily located through media files and implemented into lessons. No more having to dig through three-ring binders of overhead slides. Files and presentations may be updated and changed on the fly. Prior to the technology, teachers would have to run to the copy center to print new handouts or transparencies. The sharing and electronic storage of lessons and images has made teacher preparation faster and easier in the long run. However, it is important that the teachers in the study remember Zevenbergen & Lerman's (2008) research that cites that teachers educate students not the internet. Sharing materials is a positive, but teachers must maintain best practices in the classroom and use the sharing of materials as a library of tools to assist their teaching, not as a method of cutting corners on lesson preparation and presentation.

Teacher Jack and Teacher Jane also agreed that the post-lesson follow up work has changed the most! Simply click save to SMART Notebook and the entire lesson with any changes, digital ink notes, and recordings is saved directly to the teacher's computer where they may post the lesson to the classroom website, email it to students, or even share it with their peer network of other teachers.

Interactive Whiteboard Technology can Increase Communication Outside the Classroom

Interactive whiteboards have made communication with students easier and more regular within the high school than before. Student attendance has not noticeably changed since the

implementation of interactive whiteboards. However, electronic lessons from SMART Notebook have provided better opportunities for students to catch up after being absent. Teacher Jack, "Students email him when they're not in class to receive materials." The ability for the teacher to electronically send complete lessons and classroom notes has increased the amount of email communication between him and students. A change in teaching practice grants students the opportunity to catch up on the lesson they missed before returning to school the next day. Increased email communication and the ability to receive electronic copies of lessons also provide students with alternative study methods prior to quizzes and tests.

Unresolved Interactive Whiteboard Topics

I was surprised to learn that the teachers did not use the interactive whiteboards for grading. Companion pieces like clickers do provide opportunities for interactive whiteboards to be used for methods of assessment. However, both teachers stated that they do not regularly use clickers and even though they use electronic grade books, it is a separate system, independent from the interactive whiteboards. Therefore, there is no direct correlation between grading and interactive whiteboard use in this specific study. Beyond grading, both teachers stated that it was hard to measure an actual impact on student performance with the technology. Teacher Jack even stated "honestly, students view the SMART Board as somewhat of a novelty. I find myself having to learn and perform new practices on it to continue to wow them." Teacher Jack was not familiar with the research performed by Gary Beauchamp and John Parkinson. However, his statement echoes an excerpt from their 2005 study *Beyond the 'wow' factor,* that once the teacher has exhausted all of the interactive whiteboard routines, and the 'wow' factor has passed, these pupils may revert to less attentive behavior.

The teachers in the study had limited exposure to Universal Design for Learning (UDL) practices. However, they felt that interactive whiteboards encompass features that benefit UDL teaching methods. Interactive whiteboards have the ability to readily change font sizes, enlarge images, and highlight objects making key elements of the lesson easier to identify and read. The recording features of SMART Recording can act as an audio note taker and also provides students with the opportunity to replay entire lessons or segments when reviewing or studying for tests. The save feature gives teachers the ability to catalog materials for entire units, quarters, or even the year. Providing students with the ability to easily obtain past classroom materials is a great resource that began as an adaptation for some but actually is a feature that everyone can benefit from and ultimately makes inclusive learning easier for all.

This qualitative study does not provide any empirical evidence to support or oppose a change in student performance with the addition of interactive whiteboards. However, I conclude that interactive whiteboards have changed teaching practice. Such changes provide better access and learning opportunities for students than without the technology. In addition, I acknowledge that the support of the high school's school board, foundation, and foremost, the community is necessary for such widespread changes in practice. The willingness of parents to make personal contributions to support the implementation of interactive whiteboards is a statement in itself. Following my observations at the high school and listening to the testimonies of the participants and even without knowing the impact on student performance, it is my strong hope that other communities will consider district wide or school wide implementation of interactive whiteboard technology. I truly believe the changes I observed within the case study will ultimately lead to better learning environments for teachers, students, and the surrounding communities. While the bells and whistles of the technology could potentially wear off, I have observed a variety of changes that have stemmed from the technology. Additionally, there appeared to be an increased enthusiasm among teachers in the case study about teaching with

interactive whiteboards. Attitudes are not the only positive aspect. The teachers in the study stated that they communicated with their peers more about their lessons and how to engage students. Conversations did not take place before. These changes show that the improved technology is not the only positive factor. The changes in training, teacher sharing, and excitement all grew from the technology, which indicates value beyond its components.

Implications

The case study highlights multiple positive aspects of interactive whiteboards. However, there are some implications to adding this technology on a school-wide scale. The first and foremost is cost. With Minnesota's recent budget shortfalls, a number of K-12 school districts are required to borrow money and take out loans to pay standard operating costs that do not include technology of this scale. Although prices have reduced in the past few years, the technology remains expensive. Other school districts would likely need community support similar to the school in the study that included an active district foundation that was willing to contribute to the program along with supportive parents and school administration that placed funding the interactive whiteboard initiative as a priority.

Teacher training is another area that schools implementing interactive whiteboard initiatives need to be conscious of and invest in. I have highlighted the school's outstanding training programs throughout the case study. I believe their training programs are the secret to the success of implementing the interactive whiteboards. In my opinion, schools that do not place the same emphasis on teacher training as the school in the study will not have the same positive results as I witnessed in this study.

Extensive teacher training was also enhanced by the fact that administrators made sure teachers were using interactive whiteboards to their full potential and not simply as large screen televisions. It is important to use all the available features, not only so the school gets its full money's worth from the technology, but also to ensure that students' interest does not dwindle as they get used to the more basic features. It is also important that teachers use a variety of teaching methods. Interactive whiteboards are not the end all, cure all for teaching. Teachers must continue to use best practices and proper teaching pedagogy to engage and enlighten students.

Critical Reflections

Interactive whiteboards are a new technology with enormous potential that transform the analog classroom into a digital universe providing teachers with the ease of digital reproduction and students with better and more reliable access to materials. When completing my LAP, I performed extensive research on this topic to identify the impact on teachers, teachers' teaching, and student learning. After exhaustive research, I recommend increased use of interactive whiteboards in the classroom for their digital features, increased interest they provides students, and the positive transformations in teaching practice that stemmed from the implementation of interactive whiteboards in the high school in the case study. I understand that the cost of interactive whiteboards may be hard to justify considering the current state of the economy and limited school budgets. However, I feel that schools will receive a tangible return on investment that will justify the dollars spent on the technology. I make my recommendation with the understanding that teachers teach students not widgets and gadgets so it is absolutely imperative that teachers receive ongoing interactive whiteboard training that allows them to use the technology to its full potential.

Technology Impact

Technology plays a larger role in everyday life than it ever has before. As society evolves, technology literacy gaps can be clearly seen throughout various age demographics. I specifically included two books in my literature review that are not specific to interactive whiteboards. Rather they speak to directly to the evolution of technology and its role in society. These books serve as resources to understanding the changes that are required of K-12 classrooms to transition from its analog state to a digital environment. In *Growing Up Digital: The Rise of the Net Generation,* Tapscott speaks of the net generation (N-gen) which is native to technology and is far more familiar and comfortable using it than previous generation. Tapscott believes that teachers will be forced to adapt their practices to align with

the interests of students. No longer can teachers simply lecture by stating a series of facts, they are now required to change the way that they teach. Students are digital, their world revolves around the immediate access to friends and information that technology provides. Teachers need to implement these attributes into their lessons in order to speak the same proverbial language as their students. Web 2.0 and the transition to web applications have created platforms for teacher collaboration and syndication. These transitions in technology assist teachers' ability to evolve with the N-gen. Interactive whiteboards serve as a vehicle for teachers to deliver lessons using cutting edge technology, a pedagogy that will engage the N-gen.

In *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns,* technology is viewed as a positive disrupter to the classroom. Christiansen's viewpoint states that implementing technology will disrupt previous teaching methods and the cliché classrooms. These changes may not be immediately evident, but certainly exist. New classroom technology will transform the curriculum into a digital format that changes the resources used in replicating classroom materials and curriculum. Reproduction in the digital world is free of physical matter. Data from the computer is duplicated using series of computer code. In Christiansen's model classroom, students view classroom materials digitally rather than printouts, and voice over IP to talk to pen-pails, not the telephone. The digital disruption stretches farther than using less paper and eliminating the telephone and long-distance charges, it's the way materials are reproduced. Using cloud applications, students may log in from any internet connection and view the same materials no matter their location. Voice over IP and video chats are recorded and reproduced without using any additional hardware. Christiansen believes that these disruptions will improve K-12 students' educational experiences. These disruptions offer a fungible, fundamental change to education. The physical change may not be obvious at first, but evident over time and a clear step in evolving classrooms to reflect the interest of students and the workforce and realities of the real world.

Thomas Friedman revolutionized economics and the technology industry with his book, *The World is Flat.* In the book, Friedman creates a *change or die* mantra that indicates that technology businesses must evolve with the digital world and failure to do so will lead to their demise. Tapscott, Christiansen, and Friedman all indicate that it is necessary for our society to digitally evolve with the times. Like these three authors, I share a similar viewpoint. I feel that interactive whiteboards are one way to push K-12 education into the digital era.

Technology in use

My case study included experts within the field of education who have been deemed as interactive whiteboard experts. Understanding the composition of the research sample for the qualitative study, I expected to hear resounding endorsements for the technology. The observations, demonstrations, and interviews largely supported my expected outcome. Delving deeper than my anticipated support for the technology, I quickly learned the variety of ways that interactive whiteboards have impacted this high school and changed the way that teachers' teach. The most notable outcomes were increased teacher communication, changes to preparation for substitute teachers, and the ability to provide students with classroom materials. I also have to admit that I was personally amazed at the interactive whiteboard features and found myself on the edge of my chair while observing teacher demonstrations of the technology.

One area of the case study where I expected to receive feedback, but did not was in the area of student performance. The teachers were upfront about stating that there has not been any tracking on student performance and were careful about offering their own opinions on the topic. In their opinion, it would be extremely difficult to prove or state whether student performance has increased, decreased, or remained constant with the use of the technology. That being said, I feel that my case study lacks

measurable data and outcomes, the same critique that I offered about many of the materials included in my literature review.

I also feel it is important to recognize Beauchamp and Parkinson's (2005) "wow" factor that indicates student interest in interactive whiteboard presentations decreases the more they are exposed to the technology. Throughout the case study, I observed teachers that made efforts to learn about and include new interactive whiteboard ideas and features. As mentioned, Teacher Jane consistently seeks ideas from the SMART Technologies website and Teacher Tube. The technology specialist continued networking and research is another safeguard against the decreased wow factor described in Beauchamp and Parkinson (2005). I feel that the forward planning and thinking of the high school in the study reduces the chances of a decline in student interest taking place. However, it is an essential factor for other districts and schools to consider prior to implementing the technology.

Because of the wow factor and its potential impacts, other districts and schools should recognize the emphasis the school in the study placed on teacher training. Zevenbergen and Lerman (2008) noted that teachers teach students, not technology. As shown in their research, interactive whiteboards are only as good as the person using them. The intensive training required by the school in the current study not only taught teachers how to use interactive whiteboards, it also created a new style of community among the teachers. This new community style included increased lesson sharing, increased sharing of ideas for the technology, and volunteer group meetings that acted as training sessions. These communities stretched beyond the walls of the school. As mentioned, Teacher Jane used online resources including Teacher Tube and the SMART technologies website for additional interactive whiteboard ideas. These web 2.0 platforms provide opportunities for online collaboration, networking, and idea sharing. Observing the positive impact the school's training model had I would recommend that districts and schools plan support for the training model and professional development

on interactive whiteboards prior to implementing the technology itself as well as ongoing professional development focused on the technology.

Reflection

Currently I work for the Minnesota High Tech Association (MHTA), a non-profit trade association that supports the growth, sustainability, and global competitiveness of Minnesota's technology-based economy through advocacy, collaboration, and education. In my current position as the STEM Education Program Manager for MHTA, I create and manage programs to build public awareness of Science, Technology, Engineering and Math (STEM) education. In 2008, I organized eight high profile events to promote STEM education. I am also the Project Manager for www.getSTEM-mn.com, an interactive web portal that MHTA created in partnership with the Minnesota Department of Education. The website is designed to foster business to educator partnerships in order to provide educators with business resources. This role with MHTA has changed my career focus from becoming a classroom teacher to continuing my advocacy work for K-12 education. My outreach and promotion has two very specific focuses. The first is support for workforce applications to classroom lessons so students understand how math and science is used in the real world. Second, is to promote technology literacy and the use of technology in K-12 classrooms. Interactive whiteboard technology is strongly correlated with the second goal of my advocacy. Although, my current work is not directly related to interactive whiteboards, there has been some overlap. My advocacy for technology in the classroom is driven by the awareness that the future workplace will look, feel, and operate differently from the current environment. Classrooms need to evolve at a similar rate to prepare students for their future jobs. The digital environment exists in a series of codes comprised of 1's and 0's. This world is free of physical matter and easily reproduced. The N-gen is ahead of the curve in this world; the application to

leadership in this project is to create a classroom that is able to keep up with students today and the workplace of tomorrow.

In my education advocacy role with MHTA, I met with Minnesota State Senator Terri Bonnoff (DFL-Plymouth) in the fall of 2007 to discuss the use of technology in the classroom. Senator Bonnoff is a strong supporter of technology in the classroom and a major champion of interactive whiteboards. The Minnetonka school district, which Senator Bonnoff represents, has a district wide interactive whiteboard initiative similar to the school in the case study. Meeting with Senator Bonnoff was my first experience with interactive whiteboards in K-12 classrooms. My initial meeting was followed by a visit with Senator Bonnoff to the Minnetonka School district where we attended an open house that displayed the use of interactive whiteboards. Seeing the use of the technology and the students' excitement in the classroom had a lasting impact and left me thirsting to learn more about the new and exciting technology in the education field. This experience largely influenced my decision to research interactive whiteboard technology for my LAP. Although MHTA is not directly affiliated with interactive whiteboard programs it is a topic that I am asked to comment on from time to time.

My MHTA work experience has exposed me to other classroom technology trends beyond interactive whiteboards. I have also met with State Senator Kathy Saltzman (DFL-Woodbury). Senator Saltzman is another strong proponent of technology in the K-12 classroom. Oak Land Junior High in Lake Elmo, which Senator Saltzman represents, has a one-to-one computer initiative that provides each student with a laptop computer. I visited Oak Land Junior High in the winter of 2008 to observe their program. Oak Land's program is an amazing example of technology in the classroom. Similar to interactive whiteboards, MHTA does not have any direct programs associated with one-to-one computer initiatives. I do however continue to learn about these and other amazing advancements of technology in the K-12 classroom as part of my current position. That being said, I wanted to complete a

LAP project that would have relevance and meaning to my current profession. Interactive whiteboards were a natural fit. They are K-12 technology that my role at MHTA supports and I personally felt that they had an impact on education following my observations at Minnetonka schools with Senator Bonnoff.

My initial research for this project began in my research methods class. The topic grew to be more and more exciting as I progressed through the class and drafted the required research design. However, I was amazed by the relatively small amount of empirical evidence that supported or opposed interactive whiteboard technology. The topic is clearly a new issue; however, I felt that its immediate popularity and wildfire growth would have spawned studies with cold hard facts. A year and a half later, quantitative studies on interactive whiteboards remain few and far between. However, I have found value in the case studies and qualitative examples and set out with the intention to provide a similar value to readers of my LAP.

Prior to starting my research I witnessed student reactions to interactive whiteboards from my tour of Minnetonka schools with Senator Bonnoff. The excitement of elementary school students was almost indescribable. The students were literally jumping out of their seats to assist the teacher with interactive whiteboard lessons and activities. This experience allowed me to view the technology from a student's point of view and see their reactions. From that standpoint, I was unaware of the teacher's excitement around interactive whiteboards. Prior to my research, I did not think that teachers would view the technology as what Christensen (2008) would refer to as a positive disruption. Rather, I believed that only a select few teachers would be advocates for the technology and the rest would simply view the additional training and changes to preparation and lesson plans as a burden, rather than a convenience. Additionally, I thought that technology immigrants would have a difficult time transitioning out of the analog world that used printouts and hardcopies to a digital world free of these

materials. Zevenbergen and Lerman (2008) supported this hypothesis in their research that stated Interactive whiteboards are met with those who embrace new forms of technologies and juxtaposed with those who resist such reforms. Experienced teachers are generally skeptical of new forms of pedagogy while, in contrast, pre-service teachers see technology as an integral and valued component of their future practice (Zevenbergen & Lerman, 2008; Glover & Miller, 2002). I was amazed to learn how the faculty overwhelmingly accepted the technology and how it fostered peer groups in the high school in the study. I also sensed that teachers had a renewed feeling about their career and seemed re-energized about teaching as a result of the technology and teacher networking. In my work with MHTA, I often attend and present at education workshops and am continually amazed at the reaction, support, and excitement that surround interactive whiteboard technology. The overwhelming excitement poses the question of the Hawthorne affect and if teachers are riding the bandwagon of the latest trend in teaching. Following my research, it is my opinion that interactive whiteboards have created fundamental changes to teaching practice. These changes include improved presentation methods, interactive remote controls, increased communication with students, and the creation of peer-to-peer networks that were all cited in the case study. Therefore interactive whiteboard technology may be immune to the Hawthorne affect provided ongoing training and the continued addition of new whiteboard features. Additionally, the innovative functions of interactive whiteboards complete tasks that prior technologies could not perform and have inspired changes to the way teachers are teaching.

Continuing my research, I was amazed to learn about the capabilities of interactive whiteboards, most of which are performed through SMART Notebook software. My amazement continued throughout, as my research observations continually wowed me with demonstrations of SMART notebook and learned the program is extremely user friendly.

My research experience with the school in the case study allowed me to have a firsthand view of community support surrounding the technology. I was surprised to hear that the school board unanimously passed such a major investment on the first vote, but literally shocked when I heard that parents had made personal donations to provide interactive technology for classrooms. At a time when local taxes have steadily increased to support education and school bond referendums are continually in question of receiving community support I was stunned and inspired to hear of the community's overwhelming support of the district wide implementation of interactive whiteboards. Throughout this paper I have praised the teacher-training model provided by the school and the networking circles created by the teachers that are a major contributing factor to the high school's success. However, it is important to note that the community support was driven by their knowledge that the capabilities of interactive whiteboards were fundamentally different than the televisions, overhead projectors, and PowerPoint presentations that the technology would supersede. Their assessment displayed vision in leadership and the exceptional implementation and teacher training has allowed the technology to be used to its full potential.

The field research was the real learning experience of my LAP. Articles in education journals rarely surprised me or diverted from my positive opinion of interactive whiteboard technology. However, engaging with teachers, watching their demonstrations of the technology, observing their classrooms, and hearing their personal reflections on implementing the technology was a true learning experience. Although the findings are specific to the high school in the study, I feel that others in the field of education may be able to draw parallels to their own schools and better understand how they can use interactive whiteboards to change teaching practice.

Looking to the future, I feel that the research experience will assist me in my K-12 advocacy work. I started the project as an interactive whiteboard novice, but feel I now have some expertise

around the topic. I have greater awareness of the SMART Notebook software, its features, and ideas for how teachers can use it in their classroom. I am aware of the technology requirements and the lifecycles of the products. I truly feel that this new-found knowledge will assist me in my career with MHTA. As an organization that focuses on STEM education, the definition of technology is always up for debate. Some view technology as Information Technology and Computer Science while others view it from the standpoint of Career Technical Education. I feel that technology literacy is important no matter what side you're on. Interactive whiteboards have changed teaching practice and also provide students with excitement about technology that will ultimately open the doors to new and innovative opportunities.

References

Barnes, L. (2008, November/ December). Lecture-Free High School Biology Using an AUDIENCE RESPONSE SYSTEM. *The American Biology Teacher, 70* (9) 531-536. Proquest Education Journals

Beauchamp, G., Parkinson, J. (2005). Beyond the wow factor: Developing interactivity with the interactive whiteboard. *School Science Review, 86* (316), 97 – 103.

Bennett, S., Lockyer, L. (2008, September). S study of teachers' integration of interactive whiteboards into four Australian primary school classrooms. *Learning, Media and Technology, 33* (4), 289-300.

Bruun, E. (2009, February). Using digital photography and image processing for the creation of notes from the blackboard. *Innovations in Education & Teaching International*, *46*(1), 83-90. Retrieved April 26, 2009

Christensen, C., Horn, M., Johnson, C. (2008). Disruptive Class: *How Disruptive Innovation Will change the Way the World Learns.* New York: McGraw Hill.

Dufresne, R.J., Grace, W.J, Leonard, W.J., Mestre, J.P., & Wenk, L. (1996). Classtalk: Aclassroom communication system for active learning. *Journal of Computing in Higher Education,* 7,3-47.

Goodison, T. (2003, November). Integrating ICT in the classroom: a case study of two contrasting lessons. *British Journal of Educational Technology*, *34*(5), 549-566. Retrieved May 10, 2008, doi:10.1046/j.0007-1013.2003.00350.x

Goodison, T. (2002, March). ICT and attainment at primary level. *British Journal of Educational Technology*, *33*(2), 201. Retrieved May 10, 2008, from EBSCO MegaFILE database.

Guryan, J., Jacob, B., Klopfer, E., & Groff, J. (2008, March). Using technology to explore social networks and mechanisms underlying peer effects in classrooms. *Developmental Psychology*, *44*(2), 355-364. Retrieved April 26, 2009, doi:10.1037/0012-1649.44.2.355

Knight, P., Pennant, J., & Piggott, J. (2005, Summer). The power of the Interactive Whiteboard. *Micro Math*, *21*(2), 11-15. Retrieved May 10, 2008, from EBSCO MegaFILE database.

Liles, M (2005, May). Interactive Whiteboard System Drives Increased Achievement at Texas School for the Deaf. T.H.E. Journal, 32(10), 49-50. Retrieved May 10, 2008, from Wilson Education Abstracts database. (Document ID: 840271811).

Nolan, K. (2009, Winter2009). SMARTer Music Teaching. *General Music Today*, *22*(2), 3-11. Retrieved April 26, 2009, from MasterFILE Premier database.

O'Hanlon, C. (2007, June). Board CERTIFIED. T.H.E. Journal, 34(6), 30-34. Retrieved May 10, 2008, from Wilson Education Abstracts database. (Document ID: 1290093671).

Slay, H, Sieborger, I, Hodgkinson-Williams, C. (2007, August). Interactive whiteboards: Real beauty or just "lipstick"? *Science Direct, Computers and Education 51*(2008) 1321-1341.

Smith, Helen (2001, September). SmartBoard evaluation. *Kent NGFL Webpage:* www.kented.org.uk

Smith, H., Higgins, S., Wall, K., & Miller, J. (2005). Interactive Whiteboards: boon or bandwagon? A critical review of the literature

Tapscot, D. (1998). Growing Up Digital: *The Rise of the Net Generation.* New York: McGraw Hill.

Wall, K., Higgins, S., & Smith, H. (2005, September). 'The visual helps me understand the complicated things': pupil views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology*, *36*(5), 851-867. Retrieved May 10, 2008, doi:10.1111/j.1467-8535.2005.00508.x

Zevenbergen, R, Llerman, S. (2008, April). Learning Environments Using Interactive Whiteboards: New Learning Spaces or Reproduction of Old Technologies? *Mathematics Education Research Journal, 20*(1) 107 – 125.