Spring 2010

Implementation of Interactive Whiteboards by High School Mathematics Teachers: Case Studies of Change

Jeffrey Scott Hall

IMPLEMENTATION OF INTERACTIVE WHITEBOARDS BY

HIGH SCHOOL MATHEMATICS TEACHERS: CASE STUDIES OF CHANGE

by

JEFFREY SCOTT HALL

(Under the Direction of Gregory Chamblee)

ABSTRACT

The purpose of this study was to assess how mathematics teachers with varying years of Interactive Whiteboard (IWB) experience differ in their implementation of IWBs. The theoretical frameworks were constructivism and change theory. Six teachers participated in the full scale study, two in each IWB experience category: Beginner, Intermediate, and Experienced. Instruments of the Concerns Based Adoption Model were used to collect data about the participants: the Stages of Concern Questionnaire measured participants' concerns about IWBs (George, Hall, & Stiegelbauer, 2006) while the Levels of Use Interview Protocol analyzed IWB usage (Hall, Dirksen, & George, 2006). Two lessons of each participant were also video-recorded and analyzed according to the guidelines of Glover, Miller, Averis, and Door (2007). A mixed methods case study approach was utilized to compare the IWB users within and between groups. Quantitative analyses of the Stages of Concern Questionnaire indicated that IWB experience does influence concerns; teachers with more IWB experience generally reported higher Stages of Concern than less experienced IWB users. Effective collaboration with an Experienced IWB user, however, can greatly improve the concerns of a Beginner IWB user. Qualitative analyses of the Levels of Use interviews and the video-recorded lessons

indicated that IWB experience does impact usage during lessons. In general, more experienced IWB users demonstrated greater knowledge about IWB features and how to integrate them into lessons to improve student learning. Again, effective collaboration with an Experienced IWB user appeared to improve the performance of a Beginner IWB user compared to other, less experienced IWB users. Collaborations between similarly experienced participants who shared time management concerns did not seem to have as much of an impact on IWB knowledge. Based on the findings of this study, the following efforts should be pursued to maximize the benefits of IWB technology in mathematics classrooms: encourage collaboration, provide full-time access to IWB technology, use IWBs with other technologies, ensure adequate training, and properly install the IWB's projector to reduce recalibration needs.

INDEX WORDS: Concerns Based Adoption Model, Mathematics education, Educational technology, Interactive whiteboards, Change theory, Constructivism

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by

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A Dissertation Submitted to the Graduate Faculty of Georgia Southern University in

Partial Fulfillment of the Requirements for the Degree

DOCTOR OF EDUCATION

STATESBORO, GEORGIA

2010

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Electronic Version Approved:
May 2010

DEDICATION

This dissertation is dedicated to my father, my eternal inspiration,

and to my wife Lucy, the blessing of my life.

ACKNOWLEDGMENTS

I would like to offer my deepest gratitude to my committee members: To Dr. Gregory Chamblee, thank you for all your guidance and support. I learned a tremendous amount about academic research from you, and I sincerely appreciate your continued encouragement of me. Your help, from my first publication and presentation through my dissertation, has been invaluable. To Dr. Kent Rittschof, Dr. Scott Slough, and Dr. John Weaver: thank you for your generous time and consideration. Your thoughtful comments and ideas were always beneficial to me, and I feel fortunate to have worked with you all.

I would also like to thank the teachers at my research site who donated their time and energy as participants in this study. Without them, this study would not exist. They are all incredible teachers who make this world a better place for their students.

Finally, I would like to thank my family. To my father, thank you for your endless love and support. You are the reason I am a scholar today, and I will always treasure our conversations. I could not have asked for a better father. To my late mother, my first teacher: I hope you are reading this with pride in heaven. To my brother, who was always there for me growing up and who helped me survive the Academy. To the best in-laws in the world, Ben and Terry Everett, thank you for never-ending kindness. You are the true embodiment of agape. To my beautiful wife Lucy, the love of my life: Your love, support, and encouragement made this all possible, and I am forever grateful. I am truly blessed to have you in my life.

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CHAPTER ONE

INTRODUCTION

"The true creator is necessity, who is the mother of our invention."

– Plato (360 B.C.E./1989, p. 45)

Technology has always played an integral role in human development. It is, to no small extent, what distinguishes humans from other forms of life. Inventions of all sorts, from the primitive to the high tech, the cognitive to the physical, have been a fundamental hallmark of humanity. Driven primarily by necessity, technology has been used to solve problems and improve living conditions since recorded history.

Since the beginning, the key to technological growth has been education. Indeed, technology and education form a symbiotic relationship, each nourishing the other, so much so that the role of technology in education cannot be overstated. As our body of knowledge accumulates, inventions and technology beget even more inventions and technology. The invention of language and arithmetic led to writing and counting tools, printing presses and calculators, e-books and computers, each requiring more teaching and learning in order to be used effectively. Indeed, as each new technological breakthrough occurs, the need for more education to apply it almost inevitably follows.

Inventions to aid education come in two varieties: physical artifacts (such as calculators and computers) and mental artifacts (such as arithmetic and language) (Norman, 1993). Norman (1993) noted that technologies, "whether physical or mental...are equally artificial: They would not exist without human invention" (p. 5).

Some technologies, such as ink, paper, and printed textbooks, now seem so fundamental to education that one can scarcely imagine learning without them. Other technologies, such as slide rules, become widely used for a time but eventually fade away in obsolescence. Still others, such as language labs, are exposed as short-lived fads (Kean, 1993) and quickly fade from memory. As Stiegler (1994/1998) notes, "in day to day technical reality, we cannot spontaneously distinguish the long term processes of transformation from spectacular but fleeting technical evolution" (p. 21).

What, then, makes a new technology useful and valuable? The modern era of computers and Internet technologies have reignited this debate as school systems across the country and world consider the purchase of new and expensive systems for their classrooms. There is seemingly no end to the number of new educational technologies being proffered, yet many will never gain much acceptance or use. One of the few recent technologies that appears to have captured the lasting imaginations of teachers and administrators alike is the interactive whiteboard (IWB). Their increasing prominence in classrooms thus makes them a valuable subject of greater inspection and analysis.

Interactive whiteboards, which combine a computer, projector, and touch-sensitive screen into one connected system, offer a convenient and prominent way to deliver computing technology into classrooms (Gage, 2002). One of the main advantages of IWBs over individual student computer workstations is that they present a large interactive screen for an entire classroom to view and manipulate (Becta, 2003a). As a result, IWBs are becoming increasingly popular in schools around the world (Glover & Miller, 2003; Kennewell & Beauchamp, 2007). The growing popularity of IWBs

presents a need for education research to examine the efficacy and pedagogical strategies of IWB usage in classrooms.

Context of Study

This study focused on the concerns of high school mathematics teachers in a particular school as they implement interactive whiteboards in their classrooms. It is a study of educational change, a subset of curriculum studies, from the perspective of teachers. It utilized the case study method to examine and analyze the teacher participants. The following contexts are discussed in this study: constructivism, change theory, the role of technology in education, Concerns Based Adoption Model (CBAM), and interactive whiteboards.

Constructivism

Within curriculum studies, constructivism is one of the most important theories of learning. Developed initially by Jean Piaget, the theory has grown and expanded with the work of Lev Vygotsky, Maria Montessori, and many others. The theory holds that humans learn through experience and activity, building on previously learned material. It rejects the notion that knowledge can be transmitted between people as if one were a blank slate.

Change Theory

Change theory is concerned with how individuals and organizations alter their behavior over time. This theory posits that change in behavior is a cognitive process involving mental anguish and struggle. For this reason, changes in individual or organizational behavior are difficult to compel. The works of Kurt Lewin and Michael

Fullan are emphasized in this study to help explain the concerns that teachers have about implementing IWBs in their classrooms.

The Role of Technology in Education

As noted in the introduction, the role of technology in education is an important topic of research. The National Council for Teachers of Mathematics (NCTM) (2000) *Principles and Standards for School Mathematics* Technology Principle states that "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p. 24). The Technology Principle also posits that "students can learn more mathematics more deeply with the appropriate and responsible use of technology" (NCTM, 2000, p. 25). This last phrase about "the appropriate and responsible use of technology" is at the heart of successful implementations of technology in classrooms. This study is intended to shed some light on how, when, and why technology is used appropriately and responsibly.

Concerns Based Adoption Model

An interesting aspect of technology use in education is the human element. Organizations like NCTM can loudly recommend the implementation of technology in classrooms, but it is ultimately up to teachers to follow through on such recommendations. Since teachers are human (at least until technology finds a way to replace them with machines), they are susceptible to a wide range of opinions and concerns about technology, and can thus be resistant to change. Some view educational technology as mere gadgetry, perhaps for use as a harmless side show to an actual lesson or, worse, as a distraction from it. Others approach technology with paranoia and fear,

afraid that technological “progress” will disrupt and interfere with their time-honored teaching methods. Still others are eager to jump in with any new technology, relishing the chance to be pioneers and expand the boundaries of what is possible in the realm of teaching and learning.

Because all substantial technological changes provoke concerns, it is useful for agents of change to measure and understand the concerns of teachers. To that end, the Concerns Based Adoption Model (CBAM) represents a widely accepted model for examining change. Licensed for use in research by SEDL (which used to be the Southwest Educational Development Laboratory, but is now simply called SEDL to reflect its increasingly national and international mission and reach), CBAM is “a conceptual framework that describes, explains, and predicts probable teacher concerns and behaviors throughout the school change process” (SEDL, n.d., ¶ 1). It is a popular model for use in educational research about change.

CBAM consists of three main parts: Stages of Concern, Levels of Use, and Innovation Configurations. Stages of Concern examine individual concerns about change. It describes “seven different stages of feelings and perceptions that educators experience when they are implementing a new program or practice” (SEDL, n. d., ¶ 2). Levels of Use examine actual behavior when confronted with change. There are “eight behavioral profiles that describe a different set of actions and behaviors that educators engage in as they become more familiar with and more skilled in using an innovation or adopting a change” (SEDL, n. d., ¶ 3). Innovation Configurations describes how innovations are used in a classroom setting. There are “different ways an innovation may

be implemented, shown along a continuum from ideal implementation or practice to least desirable practice" (SEDL, n. d., ¶ 4). This study will only involve the first two components of CBAM.

Interactive Whiteboards

Interactive whiteboards (IWBs) are large computer-enabled screens with touch input capabilities. They are becoming increasingly popular in classrooms around the world because they essentially combine whiteboard capabilities with those of a touch-screen computer. As with all new technologies that enter the classroom, however, questions remain about their usefulness, their impact on student learning, and their training requirements, among others.

Theoretical Frameworks

This study will approach the research question from two framework perspectives: constructivism and change theory. Constructivism is an ideal framework to use in this study because it posits that individuals construct their ideas regarding an innovation both individually and socially and is developmental in nature. Change theory is also important because it posits that individuals look at innovation implementation differently over time. Together, these two frameworks will explain how mathematics teachers differ in their IWB use based on varying experience levels.

Rationale for Study

I am currently a high school mathematics teacher that has indirect access to IWBs (by borrowing a coworker's classroom that has an IWB installed). My professional interests include learning more about this increasingly common and popular classroom

technology. I am eager to better understand how to successfully implement this new technology. Additionally, I have been studying IWB use for the past two years at my high school. The efforts of my co-researchers and myself have resulted in three articles and presentations (Hall, Chamblee, & Hughes, 2008; Hall & Chamblee, 2009; Hall & Chamblee, 2010). This study built and expanded on our previous IWB research as well as the research of others.

Purpose of the Study

The purpose of this study was to assess the concerns and levels of use of high school mathematics teachers with varying degrees of IWB experience. By analyzing this information, determining a relationship between concerns, levels of use, experience, collaboration, and training was possible. A case study approach was utilized to identify any such relationships.

Research Questions

The overarching research question that this study sought to answer was, "How do mathematics teachers with varying years of IWB experience differ in their implementation of IWBs?" This question was broken down into four discrete parts:

1. What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?
2. What levels of use are indicated by mathematics teachers with differing years of IWB experience?
3. How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?

4. Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

These questions relate to the theoretical frameworks of constructivism and change theory in a variety of ways. From the perspective of constructivism, the overarching research question helped ascertain if increased IWB experience leads to more constructivist teaching methods. From the perspective of change theory, questions about concerns and levels of use tie directly into the CBAM model. These concepts are at the crux of any study involving change theory.

Significance of the Study

Information and Communication Technology (ICT) use in classrooms has been a major concern in education research for many years. One of the most famous examples of this is the Apple Classroom of Tomorrow study (Sandholtz, Ringstaff & Dwyer, 1997). This longitudinal study examined student involvement and learning, evolving roles, and behavioral/mental changes among teachers in a technologically-rich classroom. This study provided ample evidence that saturating classrooms with technology does significantly alter the education process in a variety of ways. The fast-evolving nature of technology makes it difficult to find research on every new classroom technology, however. As a result, IWBs have not been researched as widely as traditional student computer workstations, nor can prior ICT research be assumed to transfer to IWBs (Beauchamp & Parkinson, 2005).

The British Educational Communications and Technology Agency (Becta, 2003b) noted that since “interactive whiteboards are a relatively recent technology, there is not a

great deal of literature relating to them in refereed academic journals" (p. 3). The organization also noted that many IWB studies are based on teacher surveys and anecdotal evidence (Becta, 2003b). Since Becta's statements were made, new research has been performed regarding IWBs, but it is still a relatively unexplored area of study. Considering that school IWB deployment and use continues to grow rapidly, the need for further study is evident. In support of this assertion, a recent search of the ERIC database yielded fewer than 50 peer-reviewed articles about IWB research in the past five years. Therefore, the significance of this study is that it provides detailed evidence about the concerns of IWB users, how IWBs are implemented in the classroom, and how such concerns and usage levels differ based on IWB experience.

Assumptions of the Study

To a large extent, the conclusions of this study were based on data from questionnaires and interviews. The veracity of these responses must be assumed. The video-recorded lessons must also be assumed to be representative of each teacher's typical classroom IWB usage.

There were some ways to mitigate these assumptions. In the Stages of Concern Questionnaire, there were some safeguards built into the instrument in order to help identify invalid responses. For example, most statements begin with the phrase "I am concerned about...." In contrast, statement 12 begins with the phrase "I am not concerned about...." Therefore, since higher value responses always indicate stronger agreement with the statement, any respondent that answers all questions with only high or low responses is likely not reading the statements carefully enough.

To help ensure that the video-recorded lessons were representative of typical IWB usage, two different lessons from each teacher were recorded. The teachers were able to choose the dates and times that their lessons were recorded, but they were asked to pick lessons that demonstrated their common IWB practices. By video-recording two lessons of each teacher, it became safer to assume that their recordings were representative of the teachers' IWB usage. In addition, the IWB Teacher Follow-Up Questions (Appendix D) gave teachers a chance to discuss how similar the recorded lessons were to their typical IWB usage.

Limitations of the Study

There were three main limitations of this study. First was the small number of subjects involved. Since there were only nine teachers at the research site with IWBs installed in their classroom, all of whom were mathematics teachers, six of those nine subjects were chosen to participate in the full scale study and another two were chosen for the pilot study. This number allowed a balance between groups (i.e., two beginner, two intermediate, and two experienced IWB users) in the full scale study and a look at both extremes (one beginner and one experienced IWB user) in the pilot study. To compensate for the small number of subjects, each subject was video-recorded twice to provide more data and to help ensure a representative recording of each teacher's typical IWB use was obtained.

Second, the subjects were not chosen randomly. They were picked solely based on their availability, their years of experience with IWBs, their status as mathematics teachers, and the presence of IWBs in their classrooms. Given the small number of

teachers at the research site that met these qualifications, random selection was not feasible for this study.

Third, this study focused on subjects from only one school in Georgia. Therefore, it is possible that the data obtained cannot be generalized to the rest of the state, nation, or world. Given more time and resources, this study could be broadened to include mathematics teachers at other schools and at other grade levels, which is a recommended idea for further research.

This study's focus on one school, however, did present some advantages. For example, the six subjects in the study represented a significant portion of one high school's mathematics department. By analyzing their concerns and levels of use, it was possible to obtain a picture of the school's culture and attitudes toward technology.

Definition of Terms

Beginner IWB user – For this study, beginner IWB users are defined as having less than one year of experience using the technology.

Concerns-Based Adoption Model (CBAM) – A popular model dealing with educational change. It consists of three components: Stages of Concern, Levels of Use, and Innovation Configurations. It is "a conceptual framework that describes, explains, and predicts probable teacher concerns and behaviors throughout the school change process" (SEDL, n.d., ¶ 1).

Experienced IWB user – For this study, experienced IWB users are defined as having more than two years of experience using the technology.

Integrated Algebra 1 – As a result of a statewide curriculum change that began at the high school level in 2008, high school mathematics courses in the state where the research was conducted became integrated. This means that the freshman-level mathematics course, entitled "Integrated Algebra 1" in this particular county (compared to "Math 1" in other counties of the state), contains strands of algebra, geometry, statistics, and discrete mathematics. This is in contrast to the previous curriculum, which focused on each particular strand for one or two semesters at a time. When the research for this study was conducted, this new curriculum had only been in place at the high school level for approximately one and a half years.

Interactive Whiteboards (IWBs) – A general term for large, computer-powered screens with touch input capabilities. An IWB is essentially a blend of a whiteboard and a touch-screen computer. It is generally operated with a wireless stylus that mimics a dry-erase marker for whiteboards. A projector is used in conjunction with the screen to project the computer's output onto the large touch-sensitive surface. By touching the screen with the stylus, an IWB user can control the computer program in a fashion similar to a traditional mouse input device. The most common IWB products are manufactured by SMART Technologies and Promethean. IWBs of both brands were used in this study, but their functionalities are so similar that there is little significant difference between the two brands.

Intermediate IWB user – For this study, intermediate IWB users are defined as having between one and two years of experience using the technology.

Levels of Use (LoU) – A component of CBAM. There are "eight behavioral profiles that describe a different set of actions and behaviors that educators engage in as they become more familiar with and more skilled in using an innovation or adopting a change" (SEDL, n. d., ¶ 3).

Promethean Boards – A reference to the types of IWBs manufactured by Promethean. Though officially called ActivBoards by the manufacturer, the participants in this study colloquially referred to these boards as "Promethean Boards" instead, perhaps to differentiate them more from SMART-manufactured boards.

Stages of Concern – A component of CBAM. It describes "seven different stages of feelings and perceptions that educators experience when they are implementing a new program or practice" (SEDL, n. d., ¶ 2).

SMART Boards – a brand of IWB manufactured by SMART Technologies. The name "SMART Board" has become a brandnomer, like Kleenex or Coke, to refer to IWBs in general among IWB users at this research site. Teachers generically refer to all IWBs, regardless of manufacturer, by this name, even though it should refer to only those boards manufactured by SMART Technologies.

Whiteboards – The successor to chalkboards in many classrooms, whiteboards are used in conjunction with dry-erase markers instead of chalk. Interactive Whiteboards derive their name from whiteboards since they both have white writing surfaces and are used for similar purposes.

Summary

Technology and invention present continuous opportunities for innovation in the field of education. Some new technologies revolutionize the field, some help evolve it, and some are simply short-term fads. Judging by their rapid growth in schools, interactive whiteboards appear to be long-lasting additions to classrooms. Because of this growth, it is important to understand the processes of change underlying the adoption of IWBs.

Many pertinent questions are raised by the rapid growth of IWBs: What are teachers' concerns about the new technology? How are IWBs being used in classrooms? Do IWBs help improve teaching and learning, and if so, how much experience is needed with the new technology to yield these benefits? This study attempted to address these questions using the case study method. By interviewing, questioning, and video-recording a group of high school mathematics teachers with differing amounts of IWB experience, the relationship between concerns, levels of use, and IWB experience became clearer.

CHAPTER TWO

REVIEW OF THE LITERATURE

"Technology is a gift of God.
After the gift of life it is perhaps the greatest of God's gifts.
It is the mother of civilizations, of arts and of sciences....
Technology continues to grow and to liberate mankind from the constraints of the past."
– Freeman J. Dyson (2004, p. 270)

This chapter presents a review of the literature concerning topics pertinent to the study of teacher concerns and use of interactive whiteboards. Literature regarding constructivism, change theory, interactive whiteboard research, and the Concerns-Based Adoption Model are discussed. A description of a pilot study, performed as a proof-of-concept prior to the initiation of the full-scale study, is also provided.

Constructivism

Constructivism, as a theory of education, posits that "knowledge about the world does not simply exist out there, waiting to be discovered, but is rather constructed by human beings in their interaction with the world" (Gordon, 2009, p. 39). Constructivism is "premised on the belief that learners actively create, interpret, and reorganize knowledge in individual ways....With respect to instruction, this belief suggests that students should participate in experiences that accommodate these ways of learning" (Winschitl, 1999, p. 752). With its de-emphasis on lecture formats and other passive-student activities, constructivism has become a dominant learning theory around the world, guiding teachers to create lesson plans that invite active participation and inquiry from students (Pass, 2004).

Although generally considered an individualist learning theory, constructivism can be both individual- and community-based. Cobb, Perlwitz, & Underwood-Gregg (1998) note that "constructivist and sociocultural theorists agree that the construction and validation of mathematical concepts are collective as well as individual activities...[that] occur via a process of argumentation within a community" (p. 72). This theory fits with the use of IWBs as interactive learning tools in classrooms. For example, the prominent screen of an IWB is able to be seen by all students in a class, which likely allows for easier collective and individual construction of mathematical material compared to students working on individual computer workstations. Constructivism is therefore an appropriate framework for examining the implementation of IWBs.

The history of constructivism as a theory of education primarily begins with Jean Piaget and Lev Vygotsky in the early to middle part of the twentieth century (Pass, 2004; von Glasersfeld, 2005; Fosnot & Perry, 2005). Piaget's concept of constructivism was focused more on "free and individual inquiry" while Vygotsky's focus was on "culturally social inquiry," yet both held the belief that knowledge is constructed by learners and not simply discovered in nature (Pass, 2004, p. 110). As such, they believed that imparting specific skill sets or behaviors was not the goal of constructivist-based instruction, but rather "cognitive development and deep understanding [were] the foci" (Fosnot & Perry, 2005, p. 10). IWBs, with their ability to facilitate class discussion around a computer-driven display, can assist in the development of cognitive abilities and deeper understanding of academic material.

Piaget believed that thought, like technology, builds on previous knowledge, but that knowledge must be reconstructed by each individual first. It is not enough that an adult has a thought and transmits it to a child. Piaget & Inhelder (1966/2000) believed that

> In the development of the child, there is no preestablished plan, but a gradual evolution in which each innovation is dependent upon the previous one. Adult thought might seem to provide a preestablished model, but the child does not understand adult thought until he has reconstructed it, and thought is itself the result of an evolution carried on by several generations, each of which has gone through childhood. Any explanation of the child's development must take into consideration two dimensions: an ontogenetic dimension and a social dimension (in the sense of the transmission of the successive work of generations). However, the problem is somewhat analogous in both cases, for in both the central question concerns the internal mechanism of all constructivism. (p. 157)

This is the basis of Piaget's theory of constructivism, and it has gained a considerable amount of following and respect from educators and psychologists alike since he developed it.

Vygotsky held similar beliefs about learning. He believed that “education is realized through the student's own experience, which is wholly determined by the environment, and the role of the teacher then reduces to directing and guiding the environment” (Vygotsky, 1926/1997, p. 50). This did not mean that the school environment was irrelevant in Vygotsky's mind. On the contrary, he believed that

“education has always had as its goal not adaptation to an already existing environment, which may, in fact, happen anyway in the natural course of events, but the creation of an adult who will look beyond his own environment” (Vygotsky, 1926/1997, pp. 50-51). Therefore, educators are necessary to help guide children to experience and learn with the future in mind.

In the minds of Piaget and Vygotsky, would IWBs have the potential to improve learning? This is obviously an impossible question to answer, but their writings provide some clues. For example, both Piaget and Vygotsky were proponents of child play. In a discussion about the importance of child play, Vygotsky (1926/1977) noted that

> We often describe a child's development as the development of his intellectual functions; every child stands before us as a theoretician who, characterized by a higher or lower level of intellectual development, moves from one stage to another. But if we ignore the child's needs, and the incentives are effective in getting him to act, we will never be able to understand his advance from one developmental stage to the next, because every advance is connected with a marked change in motives, inclinations, and incentives. (p. 92)

Put succinctly, children learn by playing. Note that the word “play” in this context does not imply that the experience must always be pleasurable (for example, think of the emotional distress involved when a child loses a game). Rather, it means an opportunity to act, to explore, to be freer, and to experience. Davis (1996) would label this as progressive education, “a teaching approach that is based on the facilitation of activity, play, and personal exploration through the provision of ‘rich’ environments” (p. 135). If

IWBs increase the opportunity for children to play in school, then Piaget and Vygotsky would most likely approve of the new technology.

Piaget's and Vygotsky's theory of constructivism was considered a radical departure from the “traditional way of thinking” about knowledge acquisition, which held that “all human knowledge ought or can approach a more or less 'true' representation on an independently existing, or ontological, reality” (von Glasersfeld, 1998, p. 23). Instead, constructivism posited that “knowledge does not attempt to produce a copy of reality but...serves the purposes of adaptation” (von Glasersfeld, 1998, p. 24). This emphasis on adaptation hearkened back to the Darwin's theory of evolution and the change in organisms over time. Indeed, constructivism can be seen as an evolutionary process of learning.

The underpinnings of constructivism can be traced farther back than Piaget and Vygotsky alone. For example, the theories of constructivism advanced by Piaget and Vygotsky were both influenced by the philosophers Kant and Hegel (Pass, 2004). Piaget and Vygotsky both agreed with Kant's theory that “man can determine his own history” as well as Kant's assertion “that all knowledge enters as perception and all knowledge begins in experience” (Pass, 2004, p. 73). In *Critique of Pure Reason*, Kant (1781/1902) wrote:

> That all our knowledge begins with experience there can be no doubt. For how is it possible that the faculty of cognition should be awakened into exercise otherwise than by means of objects which affect our senses, and partly of themselves produce representations, partly rouse our powers of understanding into

> activity, to compare, to connect, or to separate these, and so to convert the raw material of our sensuous impressions into a knowledge of objects, which is called experience? (p. 43)

From Kant's connection between sensory input and knowledge, Piaget and Vygotsky perceived the role of knowledge construction, or the notion that each individual or society creates its own understanding of the world.

Hegel (1896), in his *Lectures on the History of Philosophy,* supported Kant's assertions in this matter:

> Such connection of sensuous material with categories now constitutes the facts of experience, i.e. the matter of sensation after it is brought under the categories; and this is knowledge generally. The matter of perception which pertains to the feelings or sensuous perception is not left in the determination of individuality and immediacy, but I am active in relation to it, inasmuch as I bring it into connection through the categories and elevate it into universal species, natural laws, etc.... It is only when this object of immediate perception is laid hold of and brought under universal thought determinations that experience arises therefrom, which has a claim to validity for all time. (pp. 439-440).

Hegel, like Kant, believed that experience created knowledge. His emphasis on the personal pronoun, "I," in his discussion of knowledge indicates the importance that he places on personal experience in learning.

Piaget also used Hegel's dialectics of thesis, antithesis, and synthesis to "explain the process of perception, assimilation, and equilibration" (Pass, 2004, p. 73). Again, the

emphasis on perception and equilibration connotes an evolutionary aspect to learning that was not widely accepted prior to Piaget's and Vygotsky's advancement of constructivism as a theory of learning and education. After Piaget, Vygotsky, and others set forth their theories of constructivism, educators began making the "slow, institutional transformation away from rote behaviorism, closed definitions of intelligence, and hardened perceptions of a singular, static, 'given' structure of knowledge" (Hyerle, 1996, p. 13).

Regarding constructivism and mathematics education, Piaget believed that his learning theory could explain how children learn to think with and about numbers. For example, in *The Child's Conception of Number*, Piaget (1941/1964) hypothesized that "the construction of number goes hand-in-hand with the development of logic, and that a pre-numerical period corresponds to the pre-logic level" (p. viii). He claimed that his research did "show that number is organized, stage after stage, in close connection with the gradual elaboration of [logic]" (p. viii). By demonstrating that logic and number understanding are not innate, but that students build on previous knowledge in order to conceive logic and numbers, Piaget's findings support his own theory of constructivist learning in mathematics.

Similarly, in *The Child's Conception of Geometry*, Piaget, Inhelder, and Szeminska (1960/1981) claim that

> the study of how children come to measure is particularly interesting because the operations involved in measurement are so concrete that they have their roots in perceptual activity (visual estimates of size, etc.) and at the same time so complex

> that they are not fully elaborated until sometime between the ages of 8 and 11 (depending on the amount of composition involved in the operation itself). (p. iv)

Piaget et al. (1960/1981) conclude that children develop the ability to perform mathematical measurements based on their previous experiences and learned skills. This is yet more support for his constructivist theory as it relates to mathematics.

Constructivism became popular in American mathematics classrooms during the 1980s, when "teaching mathematics was reconceived as the provision of activities designed to encourage and facilitate the constructive process" (Schifter, 2005, p. 85). The revolution toward constructivist-based teaching continues today. As evidence of this, it can be noted that constructivism has become a vital part of the modern standards-based approach in American public education. In mathematics education, a well known example of a set of national standards is the one developed by NCTM. Within these standards, Schifter (2005) notes that constructivism

> informs the principles guiding the current movement for mathematics education reform (National Council of Teachers of Mathematics, 1989, 1991, 2000) – that individuals necessarily approach novel situations by interpreting them in the light of their own established structures of understanding; that the construction of new concepts is provoked when those settled understandings do not allow satisfactory accommodation of the novel circumstance; and that this constructive activity is not simply an individual achievement but is embedded and enabled by contexts of social interaction. (p. 85)

Constructivism has become so prevalent and accepted, its theories are now embedded in the standards and principles, like those developed by NCTM, that are used by educators around the United States and the world.

As modern computer technology continues to improve and proliferate, it is conceivable that technology will become a great enabler of the constructive transformation of teaching and learning in the classroom. Interactive whiteboards are an excellent example of this potential. Constructivism is relevant to interactive whiteboards because IWBs, if used properly, represent an ideal new opportunity to transform constructivist theories into practice, particularly in the mathematics classroom.

Praxis is important to the advancement of constructivism because "the central problem that constructivist educators face is not a guiding theory, but concrete strategies and tools for institutionalizing these theoretical and practical understandings into more inclusive classrooms" (Hyerle, 1996, p. 15). IWBs have the potential to be successful constructivist tools for many reasons. First, they are visual tools. Such tools are important to constructivism because they allow students to "begin to visually integrate their own holistic forms with the tightly wound structures of information and thus interpret text" (Hyerle, 1996, p. 15). Thus, IWBs should be able to assist students in their visualization of new academic material.

Second, IWBs are powered by computers. As Hyerle (1996) claims, "one of the exciting qualities of the computer is that it may be used as a metacognitive tool....The empowering effect of the computer is that its capacity is partly a projection...of the neural networking of our minds" (p. 16). In addition, computers enable students and teachers to

manipulate data faster and more efficiently than ever before. In mathematics classes, for example, such effective data manipulation allows students to focus on the big picture of their work instead of the relative minutia of each operational step needed to solve a lengthy or difficult problem. Computer-based technologies such as graphing calculators have already begun to allow teachers and students to move beyond the time-consuming task of doing each step by hand in order to cover deeper mathematical material (Martin, 2008). This is an important goal of constructivist learning, and IWBs would be more beneficial in classrooms if they could support this goal.

Third, IWBs invite interaction and activity. This is beneficial to education because "sociocultural and cognitive theorists both highlight the crucial role that activity plays in mathematical learning and development" (Cobb, 2005, p. 41). This promotes the creation of "dynamic classrooms" that make mathematics education "a process of discovery and intellectual debate rather than the process of replication and rote memorization" (Weaver, 2001, p. 20). IWBs are valuable because teachers believe that students are more easily encouraged to participate in classrooms that have IWBs in use (Hall, Chamblee, & Hughes, 2008). In these classrooms, students are motivated by the technology to stand in front of their peers and interact with the IWB in order to solve mathematics problems. This represents "mathematics as produced in social practices rather than as collections of knowledge independent of practices" (Appelbaum, 1995, p. 100). The attraction of IWB technology to students, even after the initial novelty wears off, is a benefit to those teachers who desire to motivate and keep their students active and engaged in their learning.

The combination of a classroom-sized, student-manipulable, visual tool powered by a computer is what makes an IWB such a compelling tool for constructivist teaching and learning. Prior to the introduction of IWBs, the most comparable educational technology would have been individual computer workstations in a lab or classroom. While such workstations have their benefits, they do not offer a comparable community learning environment as IWBs. Assuming that IWBs are utilized properly by teachers, there is great potential for this new technology to help create a more ideal constructivist classroom.

Change Theory

Change theory is concerned with how individuals and organizations alter their behavior over time. One of the earliest change theorists, Kurt Lewin, asserted that "human change, whether at the individual or group level, was a profound psychological dynamic process that involved painful unlearning without loss of ego identity and difficult relearning as one cognitively attempted to restructure one's thoughts, perceptions, feelings, and attitudes" (Schein, 1999, p. 59). Change in behavior is due to a cognitive process marked by mental anguish and struggle, thus explaining why change in individual or organizational behavior can be so difficult to enact.

In addition, according to Bargal, Gold, and Lewin (1992), "[Kurt] Lewin's fundamental concept...[is] that psychologists [will] never be able to understand or predict human *behavior* without making the effort to learn how humans *perceive* and *conceptualize* their world...." (p. 4-5). That is, it is important to understand how people view their situation in order to understand their behavior. This is a fundamental precept

of change theory since it is impossible to understand how and why people change their behavior unless their world view is understood.

For administrators, educators, and researchers of change, Kurt Lewin's ideas provide a way to better understand change and the forces at work with and against it. An example of this is in Lewin's (1936) *Principles of Topological Psychology*. He describes using *fait accompli,* a technique that is

> often used to force an adult to do something against his will, for instance in a political struggle. A social group may fight bitterly against the attempt to change its position. If however one succeeds in bringing about a *fait accompli* the group will accept its new position without resistance. (p. 98)

In a K-12 educational setting, such reasoning provides support to administrators to act without first securing support from teachers about controversial changes. Teachers could use this information to change classroom norms (seating charts, for example) with minimal fuss from students. Such moves might not have been popular if debates and input were welcome before the change was made, but when changes are made in a seemingly irreversible fashion, Lewin (1936) believes that people will simply conform to their new situation.

Another prominent change theorist, particularly as it relates to education, is Michael Fullan. In his call for "a new mindset of educational change" (Fullan, 1993a, p. 3), Fullan noted that most efforts at enacting educational change (such as nationalized curricula, revised school floor plans, and new instructional methods) have not yielded the expected dividends. His proposed solution is to "make the educational system a learning

organization – expert at dealing with change as a normal part of its work, not just in relation to the latest policy, but as a way of life" (Fullan, 1993a, p. 4). This way, teachers and schools become more adept at adapting to changes and potential improvements.

Fullan is also concerned with implementation. He defines it in this manner: "Implementation focuses on what happens in practice. It is concerned with the nature and extent of actual change, as well as factors and processes that influence how and what changes are achieved" (Fullan, 1992, p. 21). Focusing on implementation when studying change is important because "we do not know what has changed (if anything) unless we attempt to conceptualize and measure it directly" (Fullan, 1992, p. 21). Studying implementation also allows interested parties "to identify the reasons why innovations fail or succeed" (Fullan, 1992, p. 22). The emphasis on implementation is thus a fundamental aspect of using change theory to understand how teachers change their instructional methods.

Fullan (1993b) identified "four core capacities...[of] change capacity: personal vision-building, inquiry, mastery, and collaboration" (p. 12). These concepts of change provide an important framework for understanding teacher cognition and behavior as new technologies are introduced into their classrooms. How teachers differ in their implementation of IWBs based on their experience with the technology is at the heart of this study.

Interactive Whiteboard (IWB) Research

IWBs hold much potential to be revolutionary educational tools in the classroom. The unique capabilities of IWBs—the large screen, the touch sensitivity, the computer-

driven display—were previously impossible to duplicate in the average classroom. These characteristics hold particular allure from a constructivist perspective, which emphasizes the need for student action in learning.

As a visualization tool in the mathematics classroom, for example, IWBs have the capability to allow a teacher or student to manipulate mathematical constructs, both concrete and abstract, on a large screen for the entire class to see. This large screen could promote more discourse, perhaps even student-centered discourse, about mathematics.

These outcomes are certainly desirable from a constructivist viewpoint, but are IWBs required to achieve them? Are there not other, lower-tech workarounds that teachers could use to similar effect? Whiteboard-based lessons could allow students to write on the board, but IWBs have all the advantages inherent in computers and the Internet. An LCD projector could be connected to a computer to display software onto a screen, but this arrangement would lack the touch-sensitivity and "wow" factor (however temporary it may be) of IWBs. Although a determined and skilled teacher could create a suitable constructivist classroom without an IWB, this new technology offers a whole that is greater than the sum of its parts. The more pertinent question, then, is not if IWBs can be successful constructivist tools, but whether teachers will use them this way.

Given how new IWBs are, there is relatively little amount of research about them. In addition, the available research that does exist does not focus on utility of IWBs as a constructivist classroom tool. Among the recent IWB studies performed, the areas of focus can generally be divided into: student engagement/motivation, student learning, teacher views/perceptions, training/lesson planning, and pedagogical strategies. Much of

the existing literature is based on anecdotal evidence but does indicate promise for long-term IWB implementation and success. More research-based literature is needed, particularly longitudinal studies (Glover, Miller, Averis, & Door, 2005b).

In the area of student engagement/motivation, Becta (2003) found that IWBs generally increased student participation. Knight, Pennant, & Piggott (2005) noted that IWB use has shown "a positive impact on motivation and engagement," improved "self esteem for some pupils," and provided opportunities "to revisit images of prior learning" (p. 11). Ball (2003) recorded student comments about IWB lessons and found that students generally appreciated the graphical capabilities, increased pacing, and electronic archival records made possible by IWBs. Solvie (2004) found that students were motivated even more by IWBs when they could manipulate it themselves compared to just watching a teacher manipulate it. Beeland (n. d.) analyzed surveys and questionnaires to find that students indicate a strong preference for IWB-taught lessons.

Regarding student learning, Merrett & Edwards (2004) found that IWBs generated "evident improvement in mathematical thinking skills among students with the IWB and they were becoming more confident about discussing their findings" (p. 12). Ball (2003) found that students themselves claimed to learn more from IWB lessons. Richardson (2002) found that using mathematics programs in conjunction with an IWB allowed students to exhibit higher-order thinking skills, but technology problems could also take time away from a class period that could otherwise be spent doing traditional practice problems. Richardson (2002) also discovered that retention of material learned via mathematics software using the IWB was found to be lacking.

In the area of teacher views/perceptions, Gage (2002) praised her own classroom's IWB because it focused her students on a central computer screen rather than numerous computer screens in a traditional lab setting, which made it easier to teach a lesson. Solvie (2004) found that IWB usage became natural and practically indispensable to conducting her elementary school lessons. Beauchamp & Parkinson (2005) found that teachers try more discursive lessons as they gain technical mastery over their IWBs, teaching material in a non-linear, student-responsive fashion.

Concerning training/lesson planning, Tanner & Jones (2007) found that teachers needed training in order to successfully implement interactive lesson plans. They also needed to learn how to use the many IWB functions in order to better facilitate student learning (Tanner & Jones, 2007). Without adequate training, teachers were found to continue utilizing the same pedagogical methods of the past even though they have access to new technology (Hennessey, Ruthven, & Brindley, 2005). Ball (2003) found that lesson planning took longer for IWB lessons, but that lesson materials could be shared electronically with other teachers, thus helping to reduce planning time for groups of teachers overall.

Glover, Miller, Averis, & Door (2007) performed a longitudinal study using observations of video-taped lessons, both after a teacher initially began using an IWB and then two terms later, to examine the impact of various training methods. They discovered that “continuous mentoring either from advisors or a 'missioner' member” yielded “a more rapid progression from didactic to interactive teaching approaches” (Glover, Miller, Averis, & Door, 2007, p. 319). They also developed three classifications representing

increasing interactivity of interactive whiteboard use: Supported Didactic, Interactive, and Enhanced Interactivity (Glover, Miller, Averis, & Door, 2005a; 2007). The methods utilized by Glover, Miller, Averis, & Door (2007) were used as a basis for this present study as discussed later in this chapter and in Chapter Three.

Studies of pedagogical strategies focus on how IWBs are actually utilized in the classroom. Richardson's (2002) study examined the use of mathematical software in conjunction with an IWB. Reardon (2002) noted the IWB's capability to allow teachers to pre-record lessons for use when substitute teachers are needed to fill in during a teacher's absence as well as the archival capabilities of electronic-based lessons. Solvie (2004) found that IWBs facilitate the use of diverse lesson activities, which she noted was particularly helpful for engaging students with short attention spans such as elementary school students. Glover, Miller, Averis, & Door (2007) analyzed video-taped lessons of mathematics and modern language teachers who were self-reportedly successful using IWBs to enhance learning in their classrooms. These researchers found that "the use of new technology alone cannot lead to enhanced learning. Teachers also need training to develop awareness of the relationship between approaches to interactive learning and conceptual and cognitive development in subject areas" (Glover, Miller, Averis, & Door, 2007, p. 5). Hennessy, Deaney, Ruthven, & Winterbottom (2007) used departmental focus group interviews, lesson observations, and student and teacher interviews to analyze "the strategies that teachers used to exploit the dynamic, manipulable objects of joint reference and annotative tools afforded by [IWB] technology to foster the cognitive, social and physical *participation* of learners in whole-class

activity" (p. 283). The researchers concluded that pedagogical interactivity "was constrained by systemic school and subject cultures, curricular and assessment frameworks" (Hennessy, Deaney, Ruthven, & Winterbottom, 2007, p. 283). Wood & Ashfield (2008) used data collected from classroom observations, individual teacher interviews, and focus group discussions to discover that IWBs can support and enhance whole-class lessons of numeracy and literacy, but that the technical skill and professional knowledge of the teacher as facilitator was critical to the process.

In a study of the perceptions of users and non-users of IWBs at both the middle and high school levels, Hall, Chamblee, & Hughes (2008) found that new users were more likely to use their IWBs in the same pedagogical way that they used older technologies such as overhead projectors, while veteran users were more likely to take advantage of other capabilities that the new technology offered. In a follow-up study a year later, Hall & Chamblee (2009) re-interviewed the high school teachers to see if their perceptions and IWB use had changed over time. Their findings reinforced their earlier observation that experience matters in IWB use: teachers are likely to utilize more IWB capabilities as they gain experience and comfort with their boards. These two studies indicate that significant changes in teacher perceptions do occur over time of IWBs as more experience is gained.

A recently published large-scale study about IWBs reported significant benefits to student outcomes. Conducted by Robert Marzano (2009) and sponsored by Promethean Inc., the study examined "85 teachers in 170 classrooms" (p. 80), with some teachers

using IWBs in their lessons while other teachers did not. Marzano found "significant benefits" to using IWBs in classrooms,

> particularly among those [teachers] who had been using the devices for more than two years, were confident in their skill with the boards' features, and used them for at least 75 percent of class time. The greatest benefits appeared to be in boosting student motivation and participation. (Manzo, 2010, ¶ 19)

In general, use of the IWB resulted in a "16 percentile point gain in student achievement" (Marzano, 2009, p. 80). Significant IWB factors that improved student achievement included the use of voting devices (like the Promethean ActiVote) to provide instant feedback to students, the use of visual aids from the Internet or software, and reinforcing correct answers using IWB techniques such as triggering virtual applause and uncovering hidden material.

The use of IWBs did not always lead to improved performance, however. Marzano (2009) also found that "in 23 percent of the cases, teachers had better results *without* the interactive whiteboards" (pp. 80-81). This suggests that the technology can be a hindrance to student learning if used improperly or if it is not used to complement sound teaching practices.

Concerns-Based Adoption Model (CBAM)

To examine change in this study, the Concerns-Based Adoption Model (CBAM) was used. CBAM was initially developed in the 1970s as a model to analyze implementation and change (Hall, Wallace, & Dossett, 1973). It "evolved out of the work of Frances Fuller (1969) and others in response to the innovation focus approach to

educational change" (George, Hall, Stiegelbauer, 2006, p. 1; Newhouse, 2001). In the 1980s, as attempts to correct perceived deficiencies in public education became focused on changing organizational structures in schools, CBAM gained in prominence (Anderson, 1997). Today, CBAM continues to be used in the "current era of reform and accountability," even though modern "innovations are more complex, with multiple components, and include reform programs that span schools, districts, and even entire states" (Hall, Dirksen, & George, 2006, pp. 2-3). It is a testament to the quality and versatility of the model that it has remained relevant for over 30 years.

Within the realm of educational research and application, CBAM has become a "widely applied theory and methodology for studying the process of implementing educational change by teachers and by persons acting in change-facilitating roles" (Anderson, 1997, p. 331). It has helped teachers, administrators, researchers, and planners alike to better understand the processes of change occurring within classrooms, organizations, and schools. This ultimately allows for better decision-making and more accurate expectations about the process of implementing change.

Among the benefits of CBAM is that its "concepts and procedures...provide ways to label change process phenomena, to take positive action in facilitating change, and to predict effects" (Hall & Hord, 1987, p. viii). CBAM is an appropriate model for this study because it has previously been used to examine the adoption of educational technology and has been used to "assess teacher concerns and levels of technology implementation" (Chamblee & Slough, 2002, p. 3). CBAM and its various aspects have also been empirically validated (McKinnon & Nolan, 1989) and CBAM tools "commonly

have been used in federally sponsored research projects, dissertation research, evaluations, and many change programs" for over 30 years (George, Hall, & Stiegelbauer, 2006, p. 2).

There are three parts to the CBAM model: Stages of Concern, Levels of Use, and Innovation Configurations. Although CBAM has been used in a multitude of educational research studies in the recent past, the Stages of Concern aspect has been the common focus of a majority of these studies (Chamblee & Slough, 2004). The Stages of Concern Questionnaire, licensed by SEDL, is one of the most widely used instruments to measure educational concern over change (George, Hall, & Stiegelbauer, 2006). Only Stages of Concern and Levels of Use were investigated in this study.

By using CBAM in this study, a deeper understanding of the process of change as teachers implement IWBs in the classroom was possible. It allowed an explicit labeling of each teacher's concerns and levels of use. It could also enable educators to improve IWB implementation and improve the prediction of success with future implementation efforts in the classroom. An in-depth discussion of the CBAM model, Stages of Concern, and Levels of Use as they are applied in this study is presented in the Instruments section.

Stages of Concern

The introduction of IWBs into classrooms is a technological innovation that is undoubtedly generating some new thoughts and feelings amongst teachers, even if those thoughts and feelings are ones of disinterest and apathy. It behooves teachers, administrators, teacher development specialists, information technology personnel, and educational researchers alike to better understand what those concerns are in order to

better mitigate them. This reasoning is founded on Fuller's (1969) assertion that addressing concerns will lead to greater interest in an innovation and more mature concerns about it.

The Stages of Concern aspect of CBAM is a method of registering thoughts and feelings about change. This change (or "innovation," in the context of CBAM) can be "a new strategy, program, or practice, or it may be something that has been in use for some time" (George, Hall, & Stiegelbauer, 2006, p. 7). It is important to note that, "although we can experience many types of concerns about an innovation concurrently, an individual will perceive certain aspects of the innovation as more important than others at a given time" (George, Hall, & Stiegelbauer, 2006, p. 7). Therefore, it is natural to expect that there will be a variety of concerns whenever an innovation is implemented, and those concerns will likely be based on a variety of personal factors.

Based on this concept, seven Stages of Concern about an innovation were identified: Awareness, Informational, Personal, Management, Consequence, Collaboration, and Refocusing (George, Hall, & Stiegelbauer, 2006). The stages essentially signify the progress from a beginner to an expert regarding the use of an innovation, with expert users getting the most professional benefit out of the innovation. They are called "stages" because they entail development and growth along a continuum, with initial concerns intensifying and waning and developing into new concerns as innovations are implemented.

As George, Hall, and Stiegelbauer (2006) note, "the emergence and resolution of Concerns about innovations appear to be developmental, in that earlier concerns must

first be resolved (lowered in intensity) before later concerns can emerge (increase in intensity)" (p. 8). However, it is possible for individuals to resist change so that CBAM progression does not occur as expected (Slough, 1999). By addressing the early concerns of teachers as innovations are first introduced, their development and comfort level concerning the innovation should increase more rapidly, thus alleviating any resistance. Therefore, it is imperative that change agents identify which stage of concern a teacher occupies in order to facilitate the implementation of any given innovation.

To this end, the Stages of Concern (SoC) Questionnaire (Appendix A) was created. It is now considered "the primary tool for determining where an individual is in the stages" (George, Hall, & Stiegelbauer, 2006, p. 8). The development of the instrument took three years, and it was "tested for estimates of reliability, internal consistency, and validity with several samples and 11 innovations" (George, Hall, & Stiegelbauer, 2006, p. 11). Since its origins, the SoC Questionnaire has consistently demonstrated its validity and reliability in numerous studies. For example, the validity of the instrument was tested in 1975 with teachers from the Austin Independent School District; their SoC Questionnaire scores were consistent with ratings separately established from interviews, exhibiting correlation coefficients greater than 0.56 for Stages 1, 3, 4, and 6 and coefficients of 0.52, 0.50, and 0.45 for Stages 0, 2, and 5, respectively (George, Hall, & Stiegelbauer, 2006). Evidence of the Questionnaire's reliability is found in studies by Hall (1978), George and Rutherford (1978), and Rutherford and Loucks (1979), among others. Over time, the SoC Questionnaire has demonstrated reliability "in describing and predicting teacher progress in response to a

change effort and [can] serve as the basis for wider application of the concerns theory to research and support for implementation and change efforts" (George, Hall, & Stiegelbauer, 2006, p. 57). Given the goals of this study, the Stages of Concern Questionnaire was the most appropriate instrument for identifying teacher concerns regarding IWB implementation.

Levels of Use

In addition to identifying the concerns of teachers, it is also valuable for researchers to understand how teachers are using a new innovation. According to Hall, Dirksen, & George (2006), "at the most basic level, researchers need to know if each individual identified in the treatment group is in fact using the program, practice, or strategy" (p. 4). For this reason, the Levels of Use (LoU) instrument was created as another element of the CBAM model.

The Levels of Use element is different from Stages of Concern because it focuses on behaviors, not thoughts or feelings. It is a generic construct that can be utilized with any innovation, in any field (Hall, Dirksen, & George, 2006). LoU is best described in the following manner:

> LoU presents behavioral profiles of eight different approaches to using an innovation. The focus is on what an individual or group is doing or not doing. Each profile describes a very different set of actions and related understandings about the innovation and its use. (Hall, Dirksen, & George, 2006, pp. 5)

The eight Levels of Use are: Nonuse, Orientation, Preparation, Mechanical Use, Routine, Refinement, Integration, and Renewal (Hall, Dirksen, & George, 2006). Just as with

Stages of Concern, these levels show the progression from beginner to expert user of an innovation.

Levels of Use are determined via interviews instead of observations. By asking a series of branching questions, an interviewer can ascertain how a subject is using an innovation. Interviews are preferable to observations if time and manpower are issues. The interview results are necessarily qualitative, but a validity study has shown that the LOU interview procedure yields results that are comparable to observational judgments (Hall & Loucks, 1977). That is, the interview process is highly likely to determine the same level of use as an observation process would. For the purposes of this study, the LoU Probing Questions and IWB Teacher Follow-Up Questions (Appendix C & D), which were designed specifically for IWB implementation, should yield similarly valid and reliable data since it was adapted from the branching interview chart described by Hall, Dirksen, & George (2006, p. 18).

The Levels of Use instrument has been studied for more than 30 years (Hall, Dirksen, & George, 2006). This has included studies about the validity of the LoU interview questions as a means to assess implementation behavior as well as the applicability of the instrument to a variety of innovations and settings. The initial studies about the validity of the LoU instrument were conducted by Hall, Loucks, Rutherford, and Newlove (1975) and Hall and Loucks (1977). In one aspect of their study, Hall and Loucks (1977) found a 0.98 correlation coefficient between LoU ratings based on the Interview Protocol and LoU ratings derived by ethnographers conducting classroom observations. There was a nearly perfect direct relationship between the two types of

measurement, indicating the validity of the LoU Interview Protocol to accurately describe implementation behavior.

Studies about the applicability of the LoU instrument in a variety of settings and for a variety of innovations include those by Dominguez, Tunmer, and Jackson (1980) and Cantor (1982). The analyzed settings and innovations included vocational education, bilingual program implementation, and team teaching. Each study has demonstrated that the validity of using the LoU instrument is not dependent on the setting or innovation.

Hall, Dirksen, and George (2006) note that "the bulk of the research done using the LoU Interview Protocol has assessed implementation of an innovation." (p. 39). Some of these studies, including Francq (1983) and Dirksen (1998), indicated that higher levels of use by teachers lead to improved student performance. Such research supports the use of the LoU Interview Protocol to assess IWB implementation in this study.

Glover, Miller, Averis, & Door (2007) Classifications

The Glover, Miller, Averis, & Door (2007) study provided a framework for analyzing video-recording lessons of IWB use. For simplicity's sake, this study will be referred to by the acronym GMAD. Like the CBAM instruments, the methods and classifications from the GMAD study were used in order to answer research questions in this study.

In the GMAD study, the authors developed "a structure for analysis of the video-recorded lessons...drawing upon departmental observation practice to investigate both the presentational and pedagogic aspects of IWB use" (Glover, Miller, Averis, & Door, 2007,

p. 8). This structure involved the investigation of three aspects of each recorded lesson: lesson structure, classroom management issues, and IWB impact on effective teaching. They describe their process in this fashion:

> The lessons were recorded using a fixed camera at the rear of the room focused on the IWB and the area used by the teacher around the IWB. This limited observation of activity on some tables in classrooms but the camera recorded verbal exchanges both between pupils, and between pupil and teacher in the unseen area. Researchers ensured that the camera was functioning correctly but then left the room so that teachers were not inhibited by the presence of a further observer. (Glover, Miller, Averis, & Door, 2007, p. 7)

In addition, the researchers decided that in order "to ensure consistency five videos were independently analysed by two of the team. This resulted in an agreed framework of analysis, which was then consistently applied" (Glover, Miller, Averis, & Door, 2007, p. 9).

GMAD Classifications

One of the key findings of Glover, Miller, Averis, and Door's (2007) research was the conclusion that there are only "three approaches to teaching [that were] evident to a greater or lesser extent in each of the observed lessons" (p. 9). They are: supported didactic, interactive, and enhanced interactivity. These three classifications emphasize classroom interaction in conjunction with IWB use.

The supported didactic classification involves a teacher-centric approach that is "characterised by the teacher making some use of the IWB but only as a visual support to

the lesson and not as an integral strategy for conceptual development" (Glover, Miller, Averis, and Door, 2007, p. 9). In such a case, the IWB is incidental to the lesson and is seen as a novelty of sorts by students. The teacher is the focus of the lesson, and the IWB is used, at most, to illustrate concepts. The technology is not used to develop concepts in any new way.

The interactive classification represents a progression in IWB utilization from the supported didactic classification. With interactive teachers,

> the IWB is used to challenge pupils to think by using a variety of verbal, visual and kinaesthetic stimuli. Teachers become conversant with the technology and its uses, marked by a tendency to further explore the potential of, for example, PowerPoint and Excel, and to look for ways of using the IWB tools. The IWB becomes the focal point of pupil attention whilst it is in use, usually to illustrate, develop and test discrete concepts. (Glover, Miller, Averis, and Door, 2007, p. 9)

For teachers labeled with this classification, IWB use is becoming an integral part of the lesson and provides advantages that are not possible with more traditional teaching styles and technologies.

The enhanced interactivity classification represents the pinnacle of IWB utilization. For teachers in this classification, there is "a focus on using the technology as an integral part of most teaching in most lessons, and integrating concept and cognitive development in a way that exploits the interactive capacity of the technology" (Glover, Miller, Averis, and Door, 2007, p. 10). In addition, "teachers who reach this level of competence show considerably enhanced understanding of the learning process, talk

about the ways that technology can support learning, and show ingenuity in developing materials to meet specific learning needs" (Glover, Miller, Averis, and Door, 2007, p. 10). Teachers in this classification understand the full benefits of IWB technology, appreciate how it can benefit student learning, and make efforts to improve learning with the technology.

These three classifications provide ample guidelines for determining levels of use and how specific IWB teaching methods relate to constructivist learning. Teachers that are classified at the enhanced interactivity level are necessarily promoting those classroom conditions preferred by proponents of constructivism. Teachers at the supported didactic classification generally represent the antithesis of constructivist teaching, at least as it pertains to IWB usage. By identifying teachers according to these three classifications, a connection between their IWB concerns, levels of use, and constructivist efficacy in the classroom should become more apparent.

Research Design

There are a multitude of research design options available. For any given study, design options should be selected based on a variety of factors, such as the goals of the study, the research questions, the participants, the instrumentation, and more. Chosen options should be capable of providing valid and complete answers to research questions as much as possible.

For this study, the mixed-methods approach was also chosen because it had been employed in similar studies of educational change, such as in the study by Nicolle & Lou (2008). Mixed-methods research combines both quantitative and qualitative data in a

single study. Quantitative data were desirable for ease and clarity in comparing participants and groups. Qualitative analyses were desirable because "the seductiveness of [quantitative data] can result in a tendency to overlook complexities that may only be revealed when a combination of methodologies is employed" (Elliot, 2004, p. 135). Both methods have strengths that were useful in the context of this study.

In one mixed-methods design called a "triangulation mixed method design," researchers "simultaneously collect both quantitative and qualitative data, merge the data, and use the results to best understand the research problem" (Creswell, 2002, p. 564-565). This study combined the quantitative data from the Stages of Concern Questionnaires with the qualitative analyses of the video-recorded lessons and the interviews to better understand each subject's concerns and levels of use. The triangulation mixed method design worked best in this situation because both types of data were equally important in the context of this study.

One consideration in a mixed methods study is that qualitative analyses are often more subjective than quantitative analyses. To maintain objectivity, Tashakkori & Teddlie (1998) recommend neutrality when describing qualitative results in order to keep the researcher's voice relatively silent. However, in counterpoint to Tashakkori & Teddlie, some theorists claim that neutrality and objectivity in the pursuit of science is impossible. Kuhn (1996), in his seminal work *The Structure of Scientific Revolutions*, noted that scientific progress throughout history has not been entirely objective or neutral:

> Observation and experience can and must drastically restrict the range of admissible scientific belief, else there would be no science. But they cannot alone determine a particular body of such belief. An apparently arbitrary element, compounded of personal and historical accident, is always a formative ingredient of the beliefs espoused by a given scientific community at a given time. (p. 4)

Similarly, Harding (1991) stated that "cognitive, scientific, and epistemic absolutism are both implicated in ethical and cultural issues and are also independently problematic" (p. 140). Yet Harding (1991) still believed that "research [was] socially situated, and it can be more objectively conducted without aiming or claiming to be value-free" (p. 159). Harding (1991) argued that

> The requirements for achieving strong objectivity permit one to abandon notions of perfect, mirrorlike representations of the world, the self as a defended fortress, and the 'truly scientific' as disinterested with regard to morals and politics, yet still apply rational standards to sorting less from more partial and distorted belief. (p. 159)

Harding's (1991) call for rational scientific investigation tempered by ethical, moral, and political obligations was compelling, so it was taken into consideration during the implementation of this study.

In addition to mixed-methods, this study also used a case study approach. Stake (1995) stated that case studies "emphasize placing an interpreter in the field to observe the workings of the case, one who records objectively what is happening but simultaneously examines its meaning and redirects observation to refine or substantiate

those meanings" (pp. 8-9). It is an ideal way to examine a single participant or group in an in-depth, in-context fashion. In this study, the researcher recorded and analyzed each participant's lessons as objectively as possible, but ultimately used that information to qualitatively identify differences in IWB usage and make connections to their IWB experience levels.

Another aspect of research design involves grouping participants. Because of the limited number of subjects available at the site for researching IWB usage using a between-group comparison design, this study was a "quasi-experiment" (Creswell, 2002). In quasi-experiments, subjects are not randomly assigned into groups. Rather, they are placed into groups for inherent and unavoidable reasons. In this study, teachers were placed into groups according to their actual levels of IWB experience: beginner, intermediate, or experienced. Such labels were not randomly applied to the subjects, but were instead based on the inherent characteristics of the teachers themselves.

Another aspect of quasi-experiments is that they involve two or more groups. With three classifications based on IWB experience levels, the number of groups in this study exceeded the minimum number of groups required for quasi-experiments. This study also utilized a type of pre- and post-testing, which is a characteristic of quasi-experiments, by administering interviews before and after the video-recordings. Since there were two teachers in each IWB experience group, it was possible to compare each teacher with their peer of comparable IWB experience. In this case, a "time series" design was suggested by Creswell (2002) since each individual in each group was studied

over time. This study involved two different recorded lessons of each teacher, so the multiple observations allowed for valid within-group analyses.

Pilot Study

A pilot study was conducted prior to the prospectus defense and the collection of data for the full-scale study. It was conducted as a proof-of-concept to ensure that the aspects of the procedures intended for the full-scale study, as described in Chapter Three, worked sufficiently. The primary focus of the pilot study was to demonstrate that the video-recording process would adequately capture IWB use in the classroom. To that end, although the full-scale study required video-recording each participant twice in order to obtain more data, the pilot study only involved the video-recording of one lesson of each participant.

The pilot study also allowed a trial run of the IWB Teacher Follow-Up Questions (Appendix D) to ensure that the questions yielded informative responses. The participants were not asked to complete the Stages of Concern Questionnaire (Appendix A) nor answer the LoU Interview Protocol questions (Appendix B) and LoU Probing Questions (Appendix C). These particular interview questions were not asked because the IWB Teacher Follow-Up Questions were expected to provide enough information for the pilot study about the participants' concerns about IWBs. The Stages of Concern Questionnaire was not included in the pilot study because it is well established (as discussed in the literature review), so a trial run of it was deemed unnecessary in this study.

Two mathematics teachers at the research site were asked to participate in the pilot study. Because these teachers agreed to participate in the pilot study, they were excluded from being candidates for the full-scale study. The participants were chosen based on their IWB experience alone. In order to determine if the methods and procedures intended for the full-scale study would adequately highlight differences between experienced and beginner IWB users, one pilot study participant had less than three months of IWB use while the other pilot study participant had more than two full school years of IWB experience. Their levels of experience placed them into the "beginner" and "experienced" IWB classifications, respectively, as described in the Participants section of Chapter Three. The beginner participant was a male teacher with more than 20 years of experience in the classroom. The experienced participant was a female teacher with approximately 20 years of experience in the classroom. Both have taught mathematics at the research site for more than five years.

Each participant was video-recorded one time teaching a lesson of their choice. The participants were asked to choose a lesson that was representative of their typical IWB usage. The IWB Teacher Follow-Up Questions (Appendix D) were asked after the video-recording of the classroom lesson was completed. Along with an analysis of the video-recorded lesson, the answers to the interview questions were then used to determine the GMAD classification of each participant.

The video-recording process was conducted in a fashion similar to the Miller, Glover, Averis, & Door's (2007) study. A video-camera was positioned in the back of

each classroom, focused on the IWB. Student and teacher verbal interactions could be heard and understood, and IWB manipulations were clearly visible.

One deviation in the pilot study compared to the Glover, Miller, Averis, & Door (2007) study involved the presence of the researcher during filming. The experienced user's recording was made while the researcher remained present during the lesson, while the beginner user's recording was made in the researcher's absence. Both methods seemed to yield valid data. However, the researcher chose to be absent from the room in all recordings during the actual study to remain consistent with GMAD.

Video Analysis

In order to analyze the recordings, the methods of Glover, Miller, Averis, & Door (2007) were used. Their structure involved the investigation of three aspects: lesson structure, classroom management issues, and IWB impact on effective teaching. Ratings for each of these aspects were then considered before determining an overall classification for each participant.

The lesson structure aspect focused on the sequence of activities, how the IWB was used in the context of the lesson, student perceptions of IWB use, and other related topics. It included an analysis of "the teaching style used on a range from didactic to experiential" (Glover, Miller, Averis, & Door, 2007, p. 8). The pilot study involved a similar analysis of teaching styles.

The classroom management aspect involved an analysis of the physical classroom environment, the use of whiteboards in conjunction with the IWB, student seating, technical performance issues, and other similar concerns. The emphasis was on how the

teacher controlled the classroom with the IWB in it rather than on student discipline. This aspect was considered in this pilot study and was also analyzed in the full-scale study.

The IWB impact on effective teaching aspect was concerned with the teacher's expertise with the IWB, the amount of conceptual learning that occurred during the lesson, the types of learning styles addressed, and the lesson's influence on cognitive development of students. The pilot study similarly attempted to analyze the impact of IWB use on student learning. The full-scale study, with double the amount of recorded lessons, was expected to yield even more detailed analyses about student learning and the impact of IWBs.

In order to promote a standard analysis of each video, corroboration with multiple researchers was recommended by Glover, Miller, Averis, and Door (2007). For the pilot study and full-scale study, two researchers analyzed each video separately and discussed their findings in order to produce a single, synthesized report of each lesson. Once the analysis had occurred, a report was constructed of each recorded lesson. In Glover, Miller, Averis, & Door (2007), each recording was “summarised to facilitate comparison of data both within schools and across the range of schools” (p. 9). Since the pilot study and full-scale study occurred at a single school and involved only a single academic department, the comparison necessarily occurred between users of different IWB experience levels and within the same experience level.

Experienced User

Based on an analysis of the video-recorded lesson and the analysis of the interview responses, it was determined that the experienced IWB user was at Level IV B of the CBAM Levels of Use classification, which meant she was trying to improve the educational outcome with her IWB use. The experienced teacher demonstrated a high level of competence with her IWB. She did not physically stand next to her IWB and manipulate it with her hands or IWB stylus; instead, she sat away from the board and manipulated it with a tablet/pen input device. With the wired pen in her hand, she used the IWB software and hardware to present her lesson.

During the post-lesson interview, the experienced IWB user explained why she used the tablet/pen input device. She said that because her IWB projector was not mounted on the ceiling, it needed to be recalibrated often. Every time she or a student bumped into the projector cart, the IWB would not accurately register touches to the screen without recalibration. Since this was frustrating to her, she had decided at the beginning of the previous school year to start manipulating her IWB screen with a tablet/pen device instead. She explained that she had purchased the tablet/pen device with her own money for "approximately $60."

The experienced teacher mentioned other benefits to the tablet/pen device, as well. It allowed her to manipulate the board without having to turn her back to her students. This meant that she was able to see the class better from her seated vantage point at her desk, which aids in maintaining discipline and responding to student questions. The tablet/pen device also allowed her to "write" on the board without

blocking the view of students. Considering that the IWB was installed in the center of the existing whiteboard in the room in front of the room, a significant number of students would have had their view blocked often if the teacher were to stand in front of or to the side of the IWB.

When asked about student interaction with the IWB, the experienced IWB user said that she allows students to input data on the screen when the need arises. She gave an example of a statistics lesson that involved an investigation of data about different members of a sample. Students could come up to the IWB and input data about themselves, such as height or shoe size, into an electronic table on the screen using their hands or an IWB stylus. Students could then manipulate the data on-screen to perform their investigation. While no student interaction with the IWB was observed during the recorded lesson, the experienced user said that she does let students use the board themselves whenever the need arises.

The experienced IWB user also mentioned her desire to install the IWB software on the single student desktop in her classroom instead of her teacher laptop. She said this would allow students to control the IWB more since they would have the freedom to explore any files and programs installed on or accessible to the student workstation. With the IWB program installed on her teacher laptop, she is cautious about students having too much access to her files via the IWB.

Overall, the experienced user seemed to demonstrate a high level of skill with her IWB. Her lesson was very smooth and utilized a variety of IWB software. She definitely appeared to have a system and process in place for conducting her lessons with an IWB.

The video-recording adequately captured her lesson and made it apparent that she was an expert IWB user. She was determined to be in the Enhanced Interactivity classification according to Glover, Miller, Averis, and Door's (2007) guidelines.

Beginner User

After analyzing the video-recorded lesson and interview responses, the beginner IWB teacher was determined to be at Level III, which meant he was changing his organizational behavior to incorporate IWB use. The beginner IWB teacher explained that he was still playing with the technology and trying to understand how it would best work in his classroom. He said he had a lot of ideas for it, but seemed unsure how best to proceed with his new technological device.

The recorded lesson confirmed that the beginner user did indeed have some good ideas for IWB use. The lesson was almost entirely conducted using *The Geometer's Sketchpad* (GSP) software, which is a popular piece of "mathematics visualization software" (Key Curriculum Press, n. d., ¶ 1). He demonstrated some prior planning by having lesson notes pre-typed and geometric figures pre-drawn in various windows. He even made the lesson more theatric by having some hidden typed notes appear "magically" on the screen by changing the font color from white to black. It was clear that the beginner IWB teacher knew his way around computers and GSP software, but it was not demonstrated if he knew anything about IWB-specific functions.

For example, from this researcher's perspective, GSP is particularly valuable for teaching visual geometry concepts and most students enjoy using it. Prior to the installation of IWBs, teachers would schedule computer lab time in order to let students

use the software or use a Liquid Crystal Display (LCD) projector hooked up to a computer to project the software on a screen. With an IWB installed in the classroom, it should now be easier for teachers to demonstrate geometry concepts with the software in class and let students manipulate objects on the screen themselves. While the beginner IWB user did project the GSP objects on the board, the lesson recorded did not involve any student interaction with the IWB.

One of the reasons why there was no student interaction with the IWB was due to the set-up of the projector and the preferences of the teacher. In the post-lesson interview, the IWB beginner explained that he had turned off the touch sensitivity of his IWB because he was frustrated by the need to recalibrate the screen. Like the experienced user, his IWB did not have its projector installed on the ceiling, either. This meant that the projector would get bumped frequently, necessitating recalibration often.

Unlike the experienced user, however, the beginner simply turned off the touch functionality all together. This effectively turns his IWB into a simple screen onto which he projects his laptop display, a screen that could be duplicated with a traditional fabric pull-down screen or even a blank wall. While the functionality could be turned on again to allow touch capabilities, the fact that it was turned off indicates that touch interaction is not often utilized in the IWB beginner's classroom.

Overall, the recorded lesson and interview seemed to corroborate each other. Watching the video, it was clear that the beginner IWB user was an expert *Geometer's Sketchpad* user, but he did not demonstrate any knowledge of the IWB-specific software or any other IWB-specific functionality. He also did not allow students to interact with

the board, which was understandable in light of the interview responses he gave about deactivating his IWB's touch sensitivity. This teacher was determined to be at the supported didactic classification in regard to his IWB usage.

Pilot Study Conclusion and Lessons Learned

The pilot study succeeded in its goals. It proved that the video-recording process could adequately capture an IWB lesson for later analysis. It also yielded valuable interview responses that helped illuminate and corroborate the video-recorded lessons of both participants.

The pilot study also succeeded in highlighting one area of potential concern for the full-scale study. In both cases, the two participants, one of whom was an experienced user with more than two years of IWB experience and the other with less than three months of experience, did not choose a lesson with any student IWB interaction. This makes it more difficult to assess how the teachers use their IWB.

Fortunately, the interview responses did help in this assessment. In the interview, the experienced IWB teacher described when she let students interact with the IWB, while the beginner IWB teacher described how his IWB's touch sensitivity function was turned off. This helped clarify the differences between the two levels of users.

To help erase the ambiguity that could be caused with a single recorded lesson, the full-scale study involved the recording of two lessons per participant. This provided more data in which to assess usage levels. An extra question (question six) was also added to both interview instruments to allow teachers more freedom to discuss their IWB concerns, which helped capture a more accurate picture of each participant's IWB use.

From an IWB implementation perspective, the comments from both participants regarding their desire for ceiling-mounted projectors indicated an influence of institutional policies on collected data. Since school administrators have chosen not to install IWB projectors on ceilings due to budgetary restrictions, the teachers have had to work around the limitations of using non-stationary projectors on carts or tables. The experienced user opted for a tablet input device to alleviate the hassle of recalibrating the board and projector. The beginner user chose to disable his IWB's touch-sensitivity altogether and simply used his IWB as a projection screen. The different workarounds, while starkly demonstrating a fundamental difference between these Beginner and Experienced IWB users, is nonetheless due to a result of institutional policy instead of a characteristic of IWBs themselves. This needs be a consideration when analyzing the data from the full-scale study and other studies involving IWBs.

Summary

This chapter discussed a review of the literature related to the study of interactive whiteboards and high school mathematics teachers. Literature regarding constructivism, change theory, interactive whiteboard research, and the Concerns-Based Adoption Model were discussed. A description of a pilot study was also provided, including the lessons learned from it and the changes that were made to the full-scale study to address those lessons.

CHAPTER THREE

METHODOLOGY

"The teacher must provide the instruments which the children can use to decide things by themselves . . . a ready-made truth is only a half truth."
— Jean Piaget (Quoted in Kaufman, 1979, p. 90)

This chapter explains the research methods and procedures that were used to study teacher concerns and use of interactive whiteboards. It discusses the purpose statement, research questions, setting, and participants. It also explains the research design, instrumentation, procedures, and data analysis.

Purpose Statement and Research Questions

The purpose of this study was to determine the differences, if any, in how high school mathematics teachers implement IWBs in their classrooms based on their experience with IWBs. The overarching research question was, "How do mathematics teachers with varying years of IWB experience differ in their implementation of IWBs?" This question was broken down into four parts which were investigated in this study:

1. What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?
2. What levels of use are indicated by mathematics teachers with differing years of IWB experience?
3. How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?
4. Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation of IWBs?

Setting

Participants were members of a public high school mathematics department in a large metropolitan area in the southeastern region of the United States. The faculty size was approximately 160 teachers. The school had approximately 30 full-time and part-time mathematics teachers.

The community from which the school drew its students was suburban, relatively affluent, and diverse. The school had a population of approximately 4,000 students enrolled in grades nine through twelve during the spring semester of 2009. Regarding race/ethnicity, the student population consisted primarily of Caucasians (over 50%), with African-Americans, Hispanics, and Asians each representing approximately 10-15%. Less than 5% were Multiracial or Native American.

Despite its size and relative affluence, technology access at the research site was limited. There was one student workstation and one teacher laptop in most classrooms, and there was one computer lab with approximately 30 workstations for each academic department. There were only seven IWBs in the school at the time of this study, and all of them were located in mathematics classrooms.

Participants

Six mathematics teachers with IWBs in their classrooms participated in the study. Two teachers had less than one year of experience with IWBs, two teachers had between one to two full school years of IWB experience, and two teachers had more than two full school years of IWB experience. “Beginner IWB users” were those teachers having less than one year of IWB experience. “Intermediate IWB users” were teachers having one

year to two full school years of IWB experience. "Experienced IWB users" were teachers having more than two full school years of IWB experience. The overall technology experience of each participant was not considered in this categorization; it was based on length of IWB experience only.

Research Design

This study utilized a mixed-methods quasi-experimental case study approach. The mixed-methods aspect was selected because it enabled quantitative and qualitative methods in a single study (Johnson & Onwuegbuzie, 2004). This combination enabled the data to be analyzed with the precision of quantitative analyses and the context sensitivity of qualitative analyses (House, 1994). Qualitative analyses were conducted using the Levels of Use (LoU) interviews (Hall, Dirksen, & George, 2006), supplemental interviews, and video-recorded lessons. Quantitative analyses were involved in examining the values obtained from the CBAM Stages of Concern (SoC) Questionnaires (George, Hall, & Stiegelbauer, 2006).

In addition to mixed-methods, the case study approach was selected in order to closely examine individual participants. The video-recorded lessons, the interviews, the LoU responses, and the SoC Questionnaires all provided a holistic and in-depth view of each participant's IWB use. The case study approach allowed the employment of multiple instruments and descriptive statistics to observe and measure a variety of traits about the teachers in order to achieve a detailed, in-context view of their IWB usage.

The quasi-experimental aspect was chosen because the participants had to be assigned to groups according to IWB experience. Thus, the participants were not

randomly assigned to groups. The participants in this study were compared both within-group and between-group (Creswell, 2002). Between-group comparisons were made between the three IWB experience categories of Beginner, Intermediate, and Experienced. Within-group comparisons were made between the two participants assigned to each IWB experience category.

Instrumentation

Seven instruments were used in this study:

1) CBAM Stages of Concern Questionnaire (Appendix A)
2) Stages of Concern Questionnaire: Statement Line Items by Stage (Appendix E)
3) CBAM Levels of Use Interview Protocol (Appendix B)
4) LoU Probing Questions (Appendix C)
5) LoU Rating Sheet
6) GMAD Classification Rating Sheet
7) IWB Teacher Follow-Up Questions (Appendix D)

A description of each instrument follows.

CBAM Stages of Concern Questionnaire

The Stages of Concern Questionnaire (Appendix A) is an eight-point Likert scale consisting of 35 statement items. Each statement corresponds with one particular stage of concern. Respondents select a number between zero (irrelevant) and seven (very relevant) indicating the relevancy of each statement to their own personal concerns about an innovation. An overall raw score and percentile score for each stage can then be calculated for each participant in order to determine the relative intensity of their

concerns. The tables in Appendix E divide the 35 statements of the Stages of Concern Questionnaire into their corresponding stages (George, Hall, & Stiegelbauer, 2006).

Table 1 describes the seven CBAM Stages of Concern in the context of this study. Each stage represented a unique level of concern as a person adopts an innovation. It was adapted from George, Hall, & Stiegelbauer (2006).

Table 1

CBAM Stages of Concern related to IWB use

Stage of Concern	Expression of Concern
0. Awareness	No concern about IWBs
1. Informational	Interested in learning more IWBs
2. Personal	Wondering how IWB use will personally affect the teacher
3. Management	Concerns about time management with IWB use
4. Consequence	Concerned with IWB affect on student learning
5. Collaboration	Thinking and implementing IWB collaboration with other teachers
6. Refocusing	Developing and implementing ideas to make IWB usage even better

For this study, stage 0 was the base level that indicated no concern or interest about IWB use by the participant. Stage 1 entailed the participant wanting to learn more about IWBs. Stage 2 involved the participant wondering how IWB use will affect him or her personally. Stage 3 reflected concerns about time management as it related to IWB lesson preparation. Stage 4 involved the participant being concerned with how IWBs affected student learning and how to improve the effects. Stage 5 required a participant

to be concerned about collaboration. Finally, Stage 6 indicated the participant had begun developing and implementing ideas to make IWB usage even better.

Stages of Concern Questionnaire: Statement Line Items by Stage

The Stages of Concern Questionnaire: Statement Line Items by Stage (Appendix E) instrument was used to determine each participant' Stage of Concern based on data obtained from the Stages of Concern Questionnaire. The responses from the Questionnaire, which were numbers from zero to seven, were transferred to this instrument by line item. The number responses within each stage were summed and then converted into a percentile according to the conversion table of George, Hall, and Stiegelbauer (2006). These percentiles determined the relative intensity of each participant's concerns. These were used to classify each participant to a specific Stage of Concern.

CBAM Levels of Use

Level of use is determined based upon Level of Use (LoU) Interview Protocol (Appendix B) responses from participants. According to Hall, Dirksen, & George (2006), the "LoU interview is organized around the Decision Points and the branching format" (p. 17), meaning different questions are asked of participants depending on their given responses. The questions must be asked in order and as written in the LoU manual. The authors specifically state that "no creative paraphrasing is permitted" (Hall, Dirksen, & George, 2006, p. 17). From the branching interview questions, the researcher rated the responses using the LoU Rating Sheet and the guidelines provided by Hall, Dirksen, and George (2006).

Table 2 describes the Levels of Use: Level 0 – Non-Use, Level I – Orientation, Level II – Preparation, Level III – Mechanical, Level IV A – Routine, Level IV B – Refinement, Level V – Integration, and Level VI – Renewal (Loucks-Horsley, 1996; Hall, Dirksen, & George, 2006).

Table 2

Levels of Use relating to Interactive Whiteboards (IWBs)

Levels of Use	Behavioral Indicators of Level
0. Non-Use	No interest in using an IWB
I. Orientation	Trying to learn more about IWBs
II. Preparation	Making definite plans to use an IWB
III. Mechanical	Changing organizational behavior to incorporate IWB use
IV A. Routine	Establishing a pattern of IWB use
IV B. Refinement	Trying to improve educational outcome of IWB use
V. Integration	Coordinating and collaborating of IWB use
VI. Renewal	Seeking better alternatives to existing IWB plans and use

Note: Adapted from Hall, Dirksen, & George (2006)

For this study, Level 0 reflected a user that was either not using an IWB at all or had no interest in using one. Level I involved the participant trying to learn more about IWBs. Level II participants had definite plans to use an IWB. Level III involved the participant changing his or her organizational behavior to include IWB use. Level IV A indicated that the user had established a pattern of using the IWB. Level IV B participants were trying to improve the educational outcomes produced by IWB use. Level V involved coordination and collaboration regarding IWB implementation.

Finally, Level VI indicated that the participant was trying to find better alternatives to existing IWB plans and usage.

There are seven categories that help determine a participant's overall level of use. The seven categories are: Knowledge, Acquiring Information, Sharing, Assessing, Planning, Status Reporting, and Performing. Each category is given a score according to the guidelines of Hall, Dirksen, and George (2006), which leads to an overall LoU score based on the average of the seven categories. Table 3 summarizes the seven LoU categories.

Table 3

Summary of Level of Use Categories

Category	Description
Knowledge	What a participant knows about IWBs and their use
Acquiring Information	What type of information is being sought about IWBs
Sharing	What type of information a participant shares with others
Assessing	The focus of a participant's self-assessment regarding IWB use
Planning	What a participant plans to do with an IWB
Status Reporting	How a participant perceives his or her IWB use
Performing	What concrete actions a participant has done with an IWB

The Knowledge category is unique among the seven categories in that it is not based on behavior. Instead, it "determines what the user knows about the innovation and

its use" (Hall, Dirksen, & George, 2006, p. 58). For example, a user at LoU 0 would have limited knowledge about IWBs, while a user at LoU IVB will "not only know about effects of use of the innovation with regard to student performance, but also will know about adaptations and refinements made to the innovation and understand why these changes were made" (Hall, Dirksen, & George, 2006, p. 58). The questions in Appendix B that probe this category are Q2 and Q11.

The Acquiring Information category involves active behavior by a participant. By determining what kind of information the participant is seeking and for what purpose, it becomes easier to classify them to a specific Level of Use. A person at Level I will seek descriptive information about IWBs, while a person at Level VI will seek information about how to make significant adaptations to their IWB use. The questions in Appendix B that probe this category are Q3 and Q12.

The Sharing category highlights what subjects tell others about the IWB. As a person increases his or her level of use, the information he or she shares becomes more complex. For example, a LoU I user would share generalities about IWBs, but a LoU III user would "discuss management issues related to the challenges of using the innovation" (Hall, Dirksen, & George, 2006, p. 60). The questions in Appendix B that probe this category are Q4 and Q13.

The Assessing category involves how the user examines his or her own use of an IWB. For example, a LoU III user will examine his or her "use of the innovation with respect to the problems of logistics, management, time, schedules, resources, and general reactions of students" (Hall, Dirksen, & George, 2006, p. 62). In contrast, a LoU V user

will “appraise collaborative use of the innovation in terms of client outcomes and strengths and weaknesses of the integrated effort” (Hall, Dirksen, & George, 2006, p. 63). The questions in Appendix B that probe this category are Q5 and Q14.

The Planning category assesses the kinds of plans that users make regarding their IWB use as well as the intent behind those plans. For example, a LoU II user might say that he or she is not using his or her IWB much at the moment but is planning to attend a workshop to learn more about it. With more expertise, a LoU IVB user is more concerned with student outcomes regarding IWB use and makes longer-range plans to improve student results. The questions in Appendix B that probe this category are Q7 and Q15.

The Status Reporting category is focused on how users perceive their IWB use at the moment. A LoU III user is most concerned with “issues such as logistics, time management, and resource organization” and does not perceive himself or herself as an efficient user of IWBs yet (Hall, Dirksen, & George, 2006, p. 65). A LoU VI user is so comfortable with IWBs that he or she is trying to incorporate other innovations or make major modifications to his or her IWB use in order to improve student outcomes. The questions in Appendix B that probe this category is Q6 and Q7.

The Performing category concerns concrete actions that a user has done with regard to IWBs. A LoU IVA user will incorporate the IWB smoothly into lessons “with minimal management problems” but with “little variation in the established pattern of use” (Hall, Dirksen, & George, 2006, p. 66). A LoU V user is involved in collaborations

with other faculty members in order to improve student performance and outcomes. The questions in Appendix B that probe this category are Q6 and Q10.

Level of Use Interview Protocol

Each participant was interviewed at the beginning of the study using the LoU Interview Protocol developed by Hall, Dirksen, and George (2006). The questions were asked strictly as written. If a participant responded affirmatively to Question 8, he/she was asked Questions 10 through 16. The participants were informed prior to the interview that "the innovation" referred to the IWB installed in their classroom.

The questions in the LoU Interview Protocol are specifically designed to branch out into different tracks depending on responses provided by interviewees. These different branches correspond to the eight Levels of Use. To properly conduct a Level of Use interview, the interviewer must listen to responses and adjust the flow of questions according to the protocol established by Hall, Dirksen, and George (2006). The interviewer may not adjust the wording or paraphrase the questions or else run the risk of invalidating the reliability of the instrument as determined by Hall and Loucks (1977). Table 4 describes the purpose of each LoU Interview Protocol question. Most of the questions probe a specific category, but some separate participants into different levels.

Table 4

Purpose of each LoU Question

Question	Purpose
1. Are you using the innovation?	To separate users and nonusers
2. What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?	To probe Assessing and Knowledge Categories
3. Are you currently looking for any information about the innovation? What kind? For what purpose?	To probe Acquiring Information Category
4. Do you ever talk with others about the innovation? What do you tell them?	To probe Sharing Category
5. What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?	To probe Assessing Category
6. Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?	To probe Status Reporting and Performing Categories
7. As you look ahead to later this year, what plans do you have in relation to your use of the innovation?	To probe Planning and Status Reporting Categories
8. Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?	To separate LoU V from III, IVA, and IVB. Questions 10 through 16 are asked if a positive response is given to this question.
9. Are you considering making or planning to make major modifications or to replace the innovation at this time?	To separate LoU VI from III, IVA, IVB, and V
10. How do you work together? How frequently?	To probe Performing Category and to verify Decision Point E
11. What are the strengths and the weaknesses of this collaboration for you?	To probe Knowledge Category
12. Are you looking for any particular kind of information in relation to this collaboration?	To probe Acquiring Information Category

13. When you talk to others about your collaboration, what do you share with them?	To probe Sharing Category
14. Have you done any formal or informal evaluation of how your collaboration is working?	To probe Assessing Category
15. What plans do you have for this collaborative effort in the future?	To probe Planning Category
16. Can you summarize for me where you see yourself right now in relation to the use of the innovation?	To get a concise picture of the user's perception of his/her use or nonuse

Note: Adapted from Hall, Dirksen, and George (2006)

The first question asked, “Are you using the innovation?” This question separated IWB users from nonusers. Nonusers are classified in Levels 0, I, or II, while users are classified in Levels III through VI. Since all participants in this study were selected because they were known users of IWBs, the branch of questioning corresponding with Levels 0 through II were not required for this study.

The second set of questions was: “What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?” This was designed to probe the Assessing and Knowledge Categories.

The third set of questions was: “Are you currently looking for any information about the innovation? What kind? For what purpose?” It was designed to probe the Acquiring Information category.

The fourth set of questions was: “Do you ever talk with others about the innovation? What do you tell them?” It was designed to probe the Sharing Category and check Decision Point E. This decision point “indicates that the individual initiates changes in use of the innovation based on input from and in coordination with what

colleagues are doing" (Hall, Dirksen, & George, 2006, p. 14). It is between levels IV B and V, so for a participant to be moved up to the level V classification, he or she must have attempted collaboration with colleagues.

The fifth set of questions was: "What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?" This was used to probe the Assessing Category.

The sixth set of questions was: "Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?" This was to probe both the Status Reporting and Performing categories. It was also used to "distinguish between LoU III (user-oriented changes), LoU IV B (impact-oriented changes), and LoU IV A (no or routine changes)" (Hall, Dirksen, & George, 2006, p. 53).

The seventh set of questions was: "As you look ahead to later this year, what plans do you have in relation to your use of the innovation?" This was asked to probe the Planning and Status Reporting categories.

The eighth set of questions was: "Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?" It was used to establish if collaboration was a part of the user's routine. If the answer was affirmative

that the user was collaborating, then the user was determined to be at least at level V and not at levels III, IV A, or IV B.

The ninth question was: “Are you considering making or planning to make major modifications or to replace the innovation at this time?” This question was not intended to probe for any specific category. Instead, it was designed to separate the respondent into LoU VI, the highest level, from levels III, IV A, IV B, and V.

If the interviewee responded affirmatively to question set eight, then questions 10 through 16 were asked. These questions are designed to differentiate between a level V and level VI user. Question set 10 asked: “How do you work together? How frequently?” This was to verify that Decision Point E had been crossed and to probe the Performing category.

Question 11 asked, “What are the strengths and the weaknesses of this collaboration for you?” It was used to probe the Knowledge category. An in-depth knowledge of the strengths and weaknesses of collaboration indicates a higher classification level for the respondent.

Question 12 was: “Are you looking for any particular kind of information in relation to this collaboration?” It was used to probe the Acquiring Information category. If the user is seeking information about how to make major adaptations to their collaborative efforts, then he or she is at level VI, the highest level possible.

Question 13 asked, “When you talk to others about your collaboration, what do you share with them?” This was used to probe the Sharing category. A level V user would likely mention that he or she is focused on building skills in collaborative

discussions, while a level VI user would be more interested in discussing alternatives and modifications to his or her current IWB usage.

Question 14 was: “Have you done any formal or informal evaluation of how your collaboration is working?” It was used to probe the Assessing category. A level V user would typically respond that he or she is analyzing his or her collaborative efforts in terms of student outcomes. In contrast, a level VI user would still be concerned with student outcomes, but would be more focused on assessing different collaborative approaches to using the IWB in their classroom.

Question 15 asked, “What plans do you have for this collaborative effort in the future?” This was used to probe the Planning category. Level V users would typically respond with specific plans to coordinate with other teachers in order to improve student outcomes with the IWB. A level VI user would be more interested in collaborating with new people or outsiders in order to find better alternatives to existing IWB procedures and collaborative efforts.

Question 16 was optional, but was asked of each participant in this study. It asked: “Can you summarize for me where you see yourself right now in relation to the use of the innovation?” It was used to “get a concise picture of the user's perception of his/her use or nonuse” (Hall, Dirksen, & George, 2006, p. 54).

LoU Probing Questions

The LoU Probing Questions (Appendix C) were asked after the LoU Interview Protocol questions as needed in order to further probe the participants about their IWB concerns and usage. Table 5 describes the purpose behind each question.

Table 5

Levels of Use Probing Questions and Purpose

Question	Purpose
1. How do you typically use your IWB?	Probe participant's level of use and GMAD classification
2. What pedagogical strategies do you use with your IWB?	Probe participant's level of use and GMAD classification
3. What are your personal views about IWBs in general?	Probe for concerns about IWBs
4. What is your personal view about your own IWB usage specifically?	Probe for concerns about IWBs
5. Do you have any concerns regarding IWB use in the classroom?	Probe for concerns about IWBs
6. Do you have any other comments about IWBs?	Open-ended question for participant to elaborate about IWB use

LoU Rating Sheet

The guidelines of Hall, Dirksen, and George (2006) and the LoU Rating Sheet (Table 6) were used to determine the level of use for each category and overall rating.

Table 6

The Levels of Use Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

Note: Adapted from Hall, Dirksen, & George (2006)

The responses to the LoU Interview Protocol were used to justify a rating in each category. The average of these ratings was used to determine an overall LoU. For example, Level III was worth 3 points, Level IV A was worth 4 points, Level IV B was worth 4.5 points, and Level V was worth 5 points. The average of the seven category scores was used to determine the overall LoU rating.

GMAD Classification Rating Sheet

Glover, Miller, Averis, and Door (2007) identified three approaches to teaching in their study of IWB use that were similar to the LoU labels used in this study. They are called “Supported Didactic”, “Interactive”, and “Enhanced Interactivity” (Glover, Miller, Averis, & Door, 2007, pp. 9-10). These classifications were developed by the researchers after watching video-recorded lessons of teachers using IWBs.

The supported didactic approach is teacher-centric and utilizes IWBs primarily as visual tools instead of cognitive development tools. The IWB is used in a limited fashion in any given lesson. When an IWB is used, it is used for note-taking and other pedagogical strategies that could be easily replicated with less advanced technologies such as overhead projectors.

The interactive approach is more IWB-centric than the supported didactic approach. It involves more complex uses of the IWB, such as displaying graphics and software, in conjunction with traditional teaching tools. The IWB is used much more regularly and is used to engage student discussions.

The enhanced interactivity approach involves a high degree of IWB integration into lessons. The technology is used to make lessons student-centric as opposed to teacher-centric. Enhanced interactivity lessons demonstrate that a teacher has a deep understanding of how IWB technology can improve student learning.

These three classifications were used to describe each teacher's IWB usage in the Glover, Miller, Averis, and Door (2007) study. Each observed teacher was rated according to the three approaches in four categories: “Pedagogy”, “Engagement (in

teaching and learning)", "Social Context", and "Technology" (Glover, Miller, Averis, & Door, 2007, p. 12). That is, a teacher could be classified as using the Interactive approach in the Pedagogy category but the Supported Didactic approach in the Technology category. Table 7 describes the four categories according to the three GMAD classifications. It was adapted from Glover, Miller, Averis, and Door (2007).

Table 7

GMAD Classifications by Categories

Category	Supported Didactic	Interactive	Enhanced Interactivity
Pedagogy	IWB used as visual support only	IWB used to demonstrate concepts	IWB used to develop and test concepts
Engagement	IWB used for note-taking	IWB used to engage student discussion	IWB used to address different learning modes
Social Context	Mostly teacher-centered	Mixture of teacher- and student-centered	Mostly student-centered
Technology	Limited IWB usage	Regular IWB usage	Expanded IWB usage

Glover, Miller, Averis, and Door (2007) summarized archetypal behavior in each category in order to promote consistency among their interviewers and observers. Their research team then recorded lessons taught by 36 mathematics and foreign language teachers and conducted interviews with them. Based on these artifacts, the research team made their conclusions and labeled the teachers according to their teaching approaches in each of the four categories. The authors admitted that there was "a degree of subjectivity" in their analyses, but they chose to have multiple researchers classify each video-recorded lesson in order to make the classifications more objective (Glover, Miller, Averis, & Door, 2007, p. 11).

The GMAD classifications can be compared to most of the Levels of Use identified by Hall, Dirksen, and George (2006). Levels 0 – II, which involve nonuse or just plans to use IWB technology, are excluded because they do not correspond with the GMAD classifications, which assume that at least some usage of IWB technology is already occurring in the classroom. Table 8 illustrates the comparison between the two classification systems.

Table 8

GMAD/LoU Comparison

Glover, Miller, Averis, and Door (2007) Teaching Approaches	Hall, Dirksen, and George (2006) Levels of Use
Supported Didactic	III, IVA
Interactive	IVB
Enhanced Interactivity	V, VI

This study adopted the methodology used by Glover, Miller, Averis, and Door (2007) to analyze the two video-recorded lessons of each participant. Each of the lessons was analyzed in the areas of Pedagogy, Engagement, Social Context, and Technology. Classifications were then assigned to each area, allowing for an average overall GMAD classification to be made for each lesson. Since there were two recorded lessons of each participant, this process was done for each lesson. The two lesson classifications were then considered to assign an overall GMAD classification for each participant. The highest classification demonstrated in either of the two recorded lessons was used as the overall classification. Table 9 depicts the GMAD Classification Rating Sheet used.

Table 9

GMAD Classification Rating Sheet

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy			
Engagement			
Social Context			
Technology			
Overall			

Two researchers analyzed the video-recorded lessons using the same order of operations. The independent classifications assigned by the two researchers were then compared and discussed. Any significant differences about a participant's classification were debated until a final classification could be agreed upon. In this manner, the actual observed IWB performances of each participant in the study were classified for later comparison and discussion.

IWB Teacher Follow-Up Questions

The IWB Teacher Follow-Up Questions (Appendix D) interview was conducted shortly after the participant's two lessons had been video-recorded. Table 10 describes the purpose of each of the six questions.

Table 10

LoU Teacher Follow Up Questions and Purpose

Question	Purpose
1. Were the video-recorded lessons representative of how you typically use your IWB?	Verify that the recorded lessons captured the participant's ordinary usage of the IWB. Relates to GMAD classification.
2. How were they similar to other lessons involving your IWB?	Identify similarities to typical IWB lessons and levels of use. Relates to GMAD classification.
3. How were they different to other lessons involving your IWB?	Identify differences from typical IWB lessons and levels of use. Relates to GMAD classification.
4. What pedagogical strategy/strategies did you use in the lessons?	Probe for participant's thoughts about IWBs and levels of use. Relates to LoU classification.
5. Did you have any concerns regarding IWB use before, during, and/or after the lesson?	Probe for participant's concerns and collaborate SoC rating.
6. Do you have any other comments about IWBs?	Open-ended question for participant to elaborate about IWB use. Could relate to SoC, LoU, or GMAD ratings.

The purpose of these questions was to ensure that the video-recorded lessons were representative of each participant's ordinary IWB usage and to support the determination of the participant's CBAM Stages of Concern Questionnaire results, Level of Use ratings, and GMAD classifications. As in the LoU Probing Questions interview, the sixth question was included so participants could discuss their IWB use freely and expand on their concerns about IWB usage.

Procedures

Upon receiving approval for the pre-prospectus, the researcher sought approval from the research site's principal to perform this research at his high school. Following

approval from the principal, the researcher conducted a pilot study involving two IWB users: a beginner with less than one year of IWB experience and an experienced user with more than two years of IWB experience. The purpose of the pilot study was to establish the effectiveness of the proposed video-recording procedures and IWB Teacher Follow-Up Questions.

Upon successful defense of the prospectus, the researcher enlisted six teachers for this study. Two teachers were from each IWB experience category: beginner, intermediate, and experienced. Once the six participants were selected, the researcher conducted an initial interview with each participant individually. In the interview, the researcher explained the purpose and process of this study. The researcher instructed the participant to complete the CBAM Stages of Concern Questionnaire (Appendix A) and return it as soon as possible. The researcher also asked the participant the LoU Interview Protocol questions (Appendix B) and, if needed, the LoU Probing Questions (Appendix C).

As the CBAM Stages of Concern Questionnaires (Appendix A) were returned to the researcher, each of the participants in this study were then video-recorded teaching two actual lessons incorporating their IWB use over a one month period. The date, time, and content of the lessons that were recorded were chosen by the participants themselves. However, the researcher requested that the lessons be representative of their typical IWB usage. The camera was placed in the room by the researcher and focused on the IWB. The researcher then left the classroom so that the participant had full control of when to start and stop the recording. Each video-recorded lesson was then analyzed by the

researcher using Glover, Miller, Averis, and Door's (2007) methodology. A researcher assistant also independently watched and analyzed the videos to corroborate the researcher's conclusions. To help ensure that there was a high degree of inter-rater reliability between the two researchers, any analyses that were substantially different in the description of a single participant were discussed until a consensus was reached.

Following the video-recording of the lessons, the researcher re-interviewed each participant and asked them about their recorded lessons using the IWB Teacher Follow-Up Questions (Appendix D). This information was used to help support the CBAM instrument ratings and the GMAD classifications.

After all the data was collected, the participants were examined according to their Stages of Concern scores, Levels of Use ratings, and GMAD classifications. Comparisons were made within each IWB experience category and between each category. These analyses and comparisons were used to answer the four research questions. Figure 1 is a flow chart representing the order, process, and outcomes of the four stages of data collection used in this study

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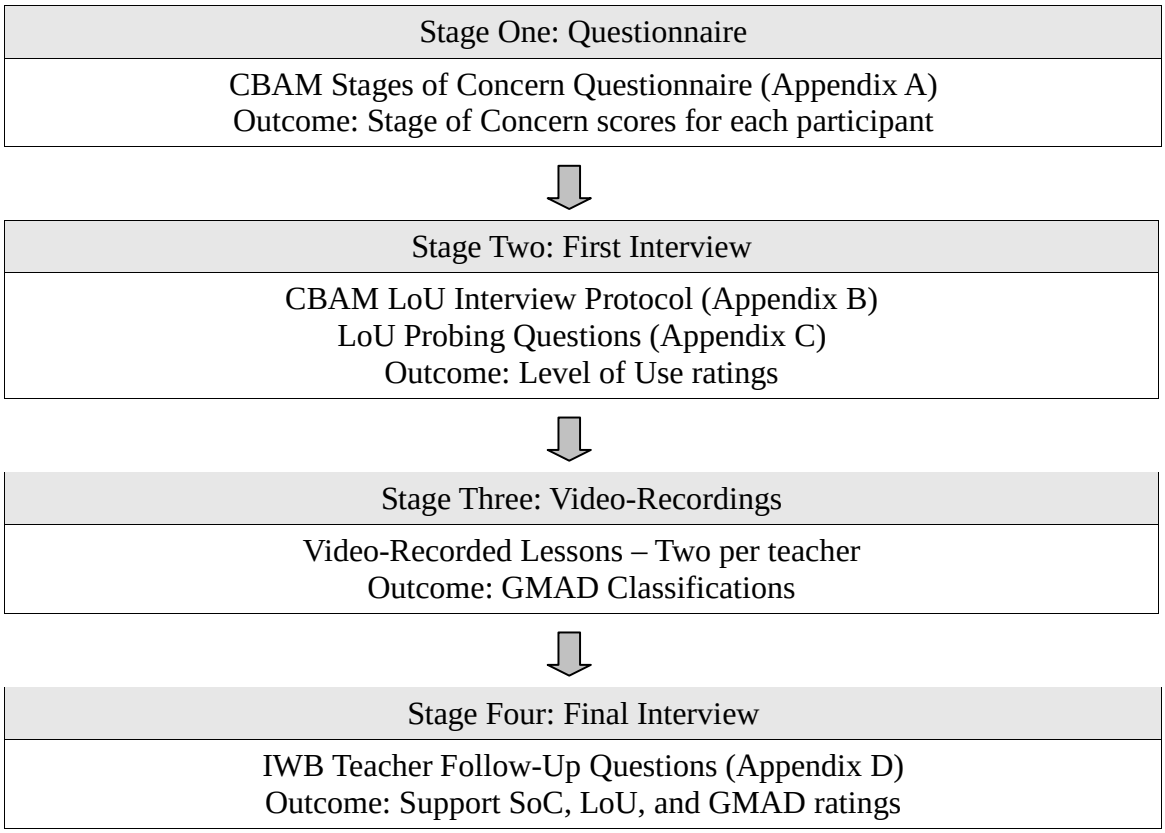

Figure 1. Data Collection Flow Chart

Data Analysis

The data generated in this study were analyzed both within-groups and between-groups (Creswell, 2002). The groups were organized according to the three classifications of IWB experience: beginner, intermediate, and experienced. There were six total participants in the full-scale study, with two participants in each category. The teacher participants were interviewed with the LoU Interview Protocol questions (Appendix B) and the LoU Probing Questions (Appendix C) prior to the video-recorded lessons and then interviewed with the IWB Teacher Follow-Up Questions (Appendix D) following the two recordings. Each participant also completed the Stages of Concern

Questionnaire (Appendix A) prior to the recordings. How each research question was analyzed follows.

Research Question One: What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?

This question was analyzed using data obtained from the Stages of Concern Questionnaires (Appendix A). The value given to each response was tabulated in the appropriate category. The values were then added to give an overall score for each category. These scores were then converted into percentiles according to the guidelines of George, Hall, & Stiegelbauer (2006). These percentiles indicated the relative intensity of each participant's concerns and determined what stage of concern each teacher was at in their implementation of IWBs. Within-group and between-group comparisons were then performed among the participants according to the three categories of IWB experience using the raw scores and percentiles (Creswell, 2002).

Research Question Two: What levels of use are indicated by mathematics teachers with differing years of IWB experience?

The Level of Use Interview Protocol (Appendix B) was used to interview each of the six participants individually. If necessary, the LoU probing questions (Appendix C) were used to clarify or expand responses. Based on a participant's responses, a level of use was determined for seven categories: Knowledge, Acquiring Information, Sharing, Assessing, Planning, Status Reporting, and Performing. The category determinations were made using the guidelines provided by Hall, Dirksen, and George (2006). An overall level of use rating was then determined based on the ratings of the seven

categories by calculating the average of the scores. Comparisons of the overall ratings were then made both within and between the IWB experience groups using the LoU ratings.

Research Question Three: How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?

Each teacher in the full-scale study was video-recorded twice teaching an IWB-based lesson. Using the classifications and descriptions provided by Glover, Miller, Averis, & Door (2007), the primary researcher and an assistant watched the videos and analyzed the lessons for IWB usage. The primary researcher and assistant worked separately in order to develop two independent, written analyses. The videos were analyzed and coded according to the GMAD classifications. If the two analyses were far off in their conclusions, the primary researcher and assistant discussed the videos and developed a consensus. The primary researcher then took the analyses for each participant and synthesized the information into one measure. This determined the classification for each participant and was used to compare and contrast the performance both within-groups and between-groups using the GMAD classifications.

Research Question Four: Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

Taking the data obtained throughout the study and the analyses required to answer Research Questions One, Two, and Three, the primary researcher determined the relationship between IWB concerns, levels of use, and actual implementation. An emphasis was placed on the results of the Stages of Concern Questionnaire, the overall

Levels of Use rating, and the GMAD classification. The following factors were also considered pertinent in determining the relationship: years of IWB experience, years of teaching experience, and the type of lesson being taught.

Summary

This chapter discussed the methods and procedures used to determine the differences in IWB implementation of high school mathematics teachers based on IWB experience. A mixed methods case study approach was determined to be the most appropriate approach for answering these questions. The theoretical frameworks of the study were constructivism and change theory, so the CBAM model was chosen as the best method for examining the participants in this study. CBAM's Stages of Concern and Levels of Use instruments were selected to classify teacher concerns and levels of use. The Glover, Miller, Averis, and Door (2007) classifications were used to analyze actual implementation behavior observed via video-recorded lessons. A pilot study was conducted prior to the full-scale study to ensure that the procedures worked as planned. Data from the CBAM instruments and the GMAD framework were then used to answer all of the research questions.

CHAPTER FOUR

DATA PRESENTATION

"The principle goal of education is to create men and women
who are capable of doing new things,
not simply repeating what other generations have done..."
— Jean Piaget (Quoted in Kohn, 2000, p. 116)

The significance of this study is that it provides an in-depth analysis of teacher concerns and behavior regarding interactive whiteboard use in a single high school mathematics department. The primary research question that this study sought to answer was, "How do mathematics teachers with varying years of IWB experience differ in their implementation of IWBs?" This question was broken down into four discrete parts:

1. What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?
2. What levels of use are indicated by mathematics teachers with differing years of IWB experience?
3. How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?
4. Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

This chapter will report the findings of the study as they relate to each of the research questions. The sections are: Participants, Participant IWB Room Configuration, Research Question One, Research Question Two, Research Question Three, Research Question Four, and Summary.

Participants

There were six participants in the full-scale study. For the sake of anonymity, they will each be assigned and referred to by a letter designation. The following are demographical descriptions of each participant.

Participant A

Participant A was classified as “Beginner” IWB user and was a female teacher in her mid-twenties with approximately five-ten years of high school mathematics teaching experience. During this study, she was teaching a freshman-level mathematics course called Integrated Algebra 1 and a sophomore-level mathematics course called Integrated Geometry. Each course consisted of algebra, geometry, statistics, and other assorted mathematics topics in an integrated format.

It is important to note that Participant A was involved in a collaborative experiment involving two other mathematics teachers while this study was conducted. Her classroom had a removable wall that allowed her to combine two classrooms into one large classroom of approximately sixty student seats. Each of the two classrooms had Promethean IWBs installed in them, so when the wall was removed, the resulting large classroom had two IWBs available for use. The teacher whose room combined with Participant A's room to make one large classroom was also a beginning IWB user, so she was not asked to participate in this study since only two beginner IWB user participants were needed for this study.

Participant A and her team teacher in the shared room were both beginner IWB users, but they collaborated with a third teacher (Participant F in this study) who was the most experienced IWB user at the school. His classroom was located next door, but it was not accessible via a removable wall. Therefore, while he provided extensive collaborative help to Participant A, they did not typically teach in the same room at the same time.

Participant B

Participant B was a Beginner IWB user in his early twenties with less than five years of teaching experience. His primary teaching responsibilities were the freshman-level mathematics course entitled Integrated Algebra 1, the sophomore-level Integrated Geometry, and a remedial class called Integrated Geometry Strategies. The Strategies course was an elective designed to provide a second hour of mathematics instruction per day for at-risk mathematics students. It did not have a curriculum of its own, but rather provided extra instruction in support of the Integrated Algebra 1 course.

At the time of the study, Participant B had an IWB installed in his classroom for approximately six months. As such, he was classified as a "Beginner" IWB user. Prior to having the IWB installed in his classroom, he had no experience teaching with an IWB.

Participant C

Participant C was a veteran high school teacher in her mid-forties with approximately 15-20 years of teaching experience. She had her IWB installed in her

classroom for one and half years at the time of the study, placing her in the "Intermediate" category of IWB users. She was the lead Advanced Placement (AP) Statistics teacher at the school. As such, she taught two sections of AP Statistics a day. The other three classes that she taught were the sophomore-level Integrated Geometry course. She also shared a room with Participant D, a part-time teacher.

Participant D

Participant D was approximately forty years old and had taught high school mathematics for 15-20 years. She was the only part-time teacher in this study. She taught mathematics for three periods a day in the morning, followed by a lunch/study hall period, and then left work for the day. Her teaching responsibilities included AP Statistics and the second year technical diploma-level course entitled Concepts of Algebra. At the time of the study, she had access to an IWB in her classroom for one and half years (the same as Participant C, since they share the same IWB), so she was classified as an "Intermediate" IWB user.

The unique situation involving Participants C and D was noteworthy. Participant C was a full-time teacher, but she shared a room with Participant D, who taught part-time. They shared a lunch/study hall period (fourth period) and similar teaching assignments, so they were able to collaborate every day if desired. Their situation was different than Participant A's situation, who usually removed one of her walls and shared one large double-room with her neighbor in order to team teach. Participants C and D, while sharing a room, never taught in the same room at the same time.

Instead, Participant C usually "floated" to an unused classroom while Participant D taught in their room. Floating is a process often required of teachers in overcrowded schools that do not have enough classrooms. Participant D only worked the first four periods of the day, so Participant C was able to teach in her own room during the last three periods of the day.

Participant E

Participant E was the most experienced classroom teacher in the study. She was approximately in her late-forties and had been teaching high school mathematics for 20-25 years. She had had her IWB installed in her classroom for two and a half years at the time of the study, so she was classified as an "Experienced" IWB user. Only one other teacher in the school, Participant F, had been using an IWB for a longer period of time.

Participant E primarily taught the Advanced Algebra and Trigonometry course, a junior/senior-level course. She also taught the freshman-level Integrated Algebra 1 course. In addition, she was also a Remediation & Enrichment Instruction (REI) teacher, providing extra instruction to students who were either struggling or excelling in their mathematics courses. Participant E mostly provided Remediation instruction to struggling freshmen.

Participant F

Participant F was a male teacher in his mid-thirties with 10-15 years of teaching experience. His teaching schedule included five sections of freshman-level Integrated

Algebra 1, some of which were the Strategies remediation variety. He had an IWB installed in his classroom for three and a half years, which placed him in the "Experienced" category and made him the teacher with the most IWB experience in the school. As such, he had taught a summer workshop on how to implement IWBs in a classroom and was often considered the IWB expert by other teachers in the mathematics department.

Participant F's classroom was located next to Participant A's classroom, but there was not a removable wall between them. While he collaborated with Participant A and her partner teacher, they did not typically share the same classroom space with students. Doing so would have required one of the other teachers to use his classroom while he taught in the double-room.

Summary

Six teachers were chosen for this study based on their time of use with IWBs. Two users each were classified as Beginner, Intermediate, or Experienced. Four were female and two were male. The Beginner IWB users were both in their early- to mid-twenties with less than 10 years of teaching experience. The Intermediate IWB users were both in their early- to mid-forties with 15-20 years of teaching experience. The Experienced IWB users included one teacher in his mid-thirties with 10-15 years of teaching experience while the other was in her late-forties and had 20-25 years of teaching experience. Table 11 summarizes the demographic data of the six participants.

Table 11

Summary of Participants by Demographic Data

Participant	IWB time of use	Gender	Approximate Age	Approximate Years of Teaching Experience
A	Beginner	Female	Mid-20s	5-10
B	Beginner	Male	Early-20s	1-5
C	Intermediate	Female	Mid-40s	15-20
D	Intermediate	Female	Early-40s	15-20
E	Experienced	Female	Late-40s	20-25
F	Experienced	Male	Mid-30s	10-15

Participant IWB Room Configuration

Participant A

Participant A's IWB was the only Promethean-brand IWB in this study. It was also the only IWB that had its LCD projector permanently installed with an arm that extended from the top of the board. This alleviated the need to reconfigure the IWB on a routine basis.

Another unique characteristic of Participant A's IWB layout was its installation on a bare wall instead of on top of an existing whiteboard. Hers was the only classroom in this study with this configuration. The desks in the classroom were arranged so that they were directly facing the IWB. When the wall was removed so that the two neighboring classrooms were combined into one, there were approximately sixty seats directly facing two Promethean IWBs (the second board belonged to her team teacher, who did not participate in this study). In this configuration, the two existing whiteboards in the classrooms were situated to the left and right of the students.

Participant B

Participant B had his SMART Board installed in the front of his classroom. All of the student desks were facing the IWB. The IWB's LCD projector was not permanently installed, but was instead sitting on a desk in the center rear of the classroom. The IWB was installed on top of the existing whiteboard, so a large portion of the original writing surface was covered up by the IWB.

Participant C / Participant D

Participant C shared a room with Participant D, so their IWB layout was the same. The IWB in their room was a SMART Board, and it was installed in the front center of the room. It was installed on top of the existing whiteboard, so there was not much space for writing with a dry-erase marker. The IWB's LCD projector was not permanently installed in the room, but sat instead on top of a rolling cart typically intended for an overhead projector. All of the student desks were aligned to face the IWB.

Participant E

Participant E had a SMART Board installed in the front and center of her room. It was installed in the middle of the existing whiteboard, so there was not much room for writing with a dry-erase marker. All of the student desks faced the IWB. Her IWB's LCD projector was not permanently installed, but was instead situated on a rolling cart in the middle of the room, directly in front of her desk.

Participant F

Participant F changed classrooms at the beginning of the school year in which this study was conducted, so he was able to get his IWB installed on a bare wall instead of on the existing whiteboard like in his old classroom. He valued the extra writing space that a whiteboard provided, so when given the opportunity, he asked for his new IWB to be installed on an unused wall. This allowed him to have the entire whiteboard on which to write.

Participant F's new room's layout was different from Participant A's, however. While Participant A's students all sat facing the IWB (or two IWBs if the wall was removed) and had whiteboards on their left (and right if the wall was removed), Participant F's room had the IWB and whiteboard installed on walls directly opposite from each other. Therefore, if one were to face the IWB, the whiteboard would be located directly behind one's back. In order to allow students to see both boards, Participant F placed his student desks against the two side walls without installed boards and had them face the center of the classroom. In this arrangement, students on one side of the classroom faced students on the other side of the classroom. The two boards are located on their left and right so that either could be seen at any time. The SMART Board's LCD projector was not permanently installed, but sat on a rolling cart in the middle of the room.

Summary

Of the six participants in this study, only Participant A had a Promethean IWB. The others all had SMART Boards. Participant A was also the only one to have her IWB's LCD projector permanently installed in her classroom. Only Participants A and F had their IWBs installed on bare walls instead of on top of existing whiteboards. Table 12 summarizes the IWB Room Configurations of the six participants.

Table 12

Summary of IWB Room Configuration by Participant

Participant	IWB Brand	LCD Projector Permanently Installed?	IWB installed on top of existing whiteboard in classroom?
A	Promethean	Yes	No
B	SMART	No	Yes
C	SMART	No	Yes
D	SMART	No	Yes
E	SMART	No	Yes
F	SMART	No	No

Research Question One

What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?

The participant responses to the Stage of Concern Questionnaires are summarized in Appendix F by Stage and Item. The mean score for each Stage is presented along with the corresponding percentile score. The percentile scores were derived according to a conversion chart published by George, Hall, and Stiegelbauer (2006).

An analysis of the Stages of Concern Questionnaire data found that the two Beginner and two Experienced IWB users all scored "Stage 5 – Collaboration" the highest. The intermediate users were mixed with one user, Participant D, scoring "Stage 0 – Awareness" the highest and the other, Participant C, scoring "Stage 4 – Consequence" the highest. It should be noted that Participant D's high rating at Stage 0 does not indicate a lack of use of her IWB, but rather a lack of concern about her IWB.

The percentile scores, which indicate relative intensity across the Stages, produced slightly different results. Instead of being at different stages, the Intermediate users were both classified at "Stage 0 – Awareness." Participant C, whose highest mean score was at "Stage 4 – Consequence," switched to Stage 0 when her score was converted to the percentile. The Beginner and Experienced IWB users were still classified at "Stage 5 – Collaboration".

Table 13 displays the mean scores for each concern by participant. The highest mean for each participant is highlighted and typed in bold. Figure 2 displays the data from Table 13 as a line graph.

Table 14 displays the percentile scores for each concern by participant. The highest percentile for each participant is highlighted and typed in bold. Figure 3 displays the data from Table 14 as a dotted line graph.

Table 13

Summary of Stages of Concern Mean Scores by Participant

Participant	Experience Category	Stage of Concern						
		0	1	2	3	4	5	6
A	Beginner	2.6	2.6	1.4	1.4	3	**6.2**	2.8
B	Beginner	1.8	3	1.4	1	3.6	**5.2**	3
C	Intermediate	3.4	4.8	3	2	**6.2**	4	4.8
D	Intermediate	**4.4**	3.6	2	4.2	2.6	2.2	2.2
E	Experienced	2.2	1.2	0.8	1	2.8	**5.6**	2.4
F	Experienced	1.8	1	1.8	2.2	3.4	**5.6**	3.6

Note: The highest mean score for each participant is highlighted and typed in bold.

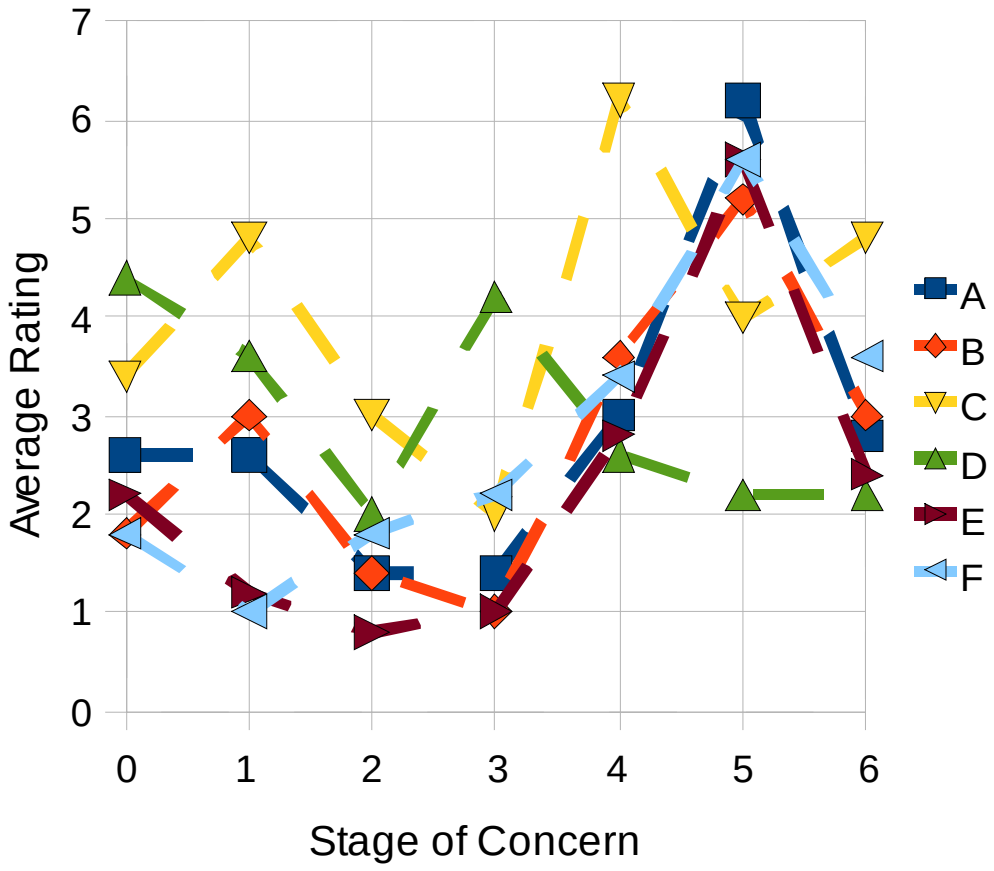

Figure 2. Stage of Concern Mean Scores by Participant.

Table 14

Summary of Stages of Concern Percentile Scores by Participant

Participant	Experience Category	Stage of Concern						
		0	1	2	3	4	5	6
A	Beginner	75	51	31	23	16	**91**	38
B	Beginner	48	57	31	15	24	**72**	42
C	Intermediate	**94**	88	57	34	82	48	81
D	Intermediate	**99**	66	41	80	11	16	26
E	Experienced	61	30	21	15	13	**80**	30
F	Experienced	48	27	39	39	21	**80**	57

Note: The highest percentile score for each participant is highlighted and typed in bold.

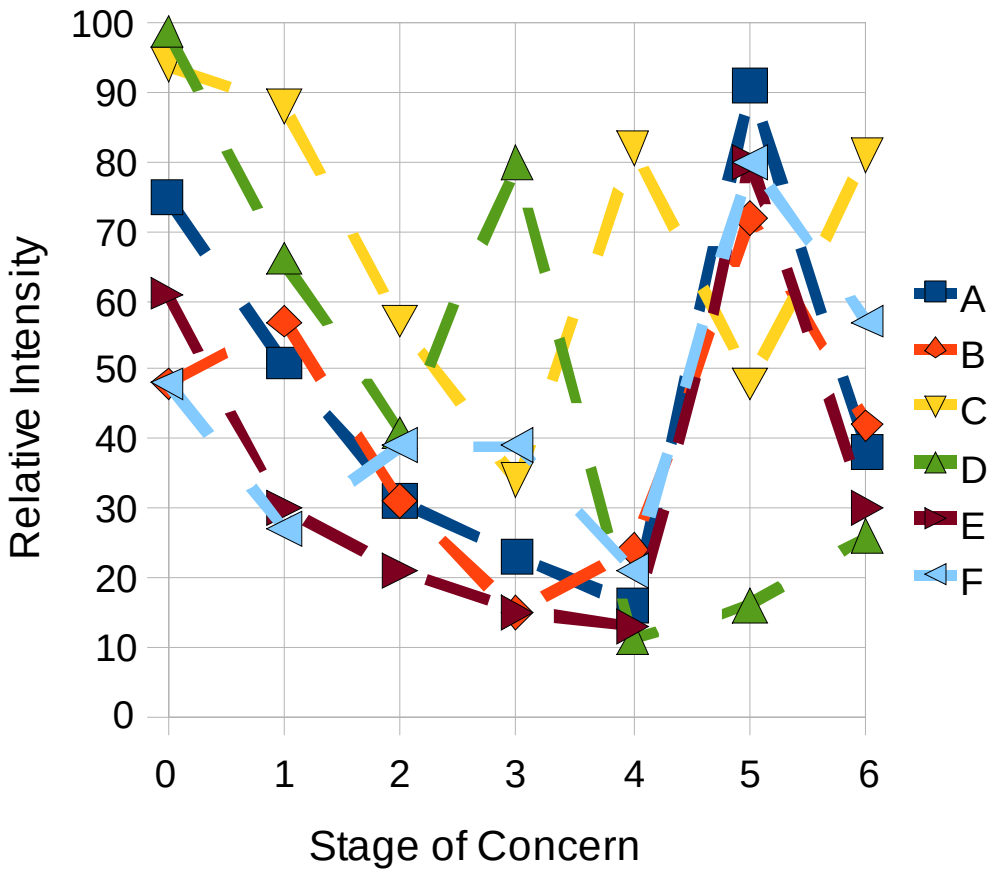

Figure 3. Stage of Concern Percentile Scores by Participant.

In order to enable easier comparisons between experience groups, the mean and percentile scores were averaged for each pair of participants. Table 15 displays the average of the mean scores of the participants within each experience category. The biggest difference is that the Intermediate users now collectively peak at "Stage 4 – Consequence." The Beginners and Experienced users still peak at "Stage 5 – Collaboration." Figure 4 presents the same information in dotted line graph form.

Table 15

Average Stages of Concern Mean Score by Experience Category

Participants	Experience Category	Stage of Concern						
		0	1	2	3	4	5	6
A & B	Beginner	2.2	2.8	1.4	1.2	3.3	**5.7**	2.9
C & D	Intermediate	3.9	4.2	2.5	3.1	**4.4**	3.1	3.5
E & F	Experienced	2	1.1	1.3	1.6	3.1	**5.6**	3

Note: The highest average score for each participant is highlighted and typed in bold.

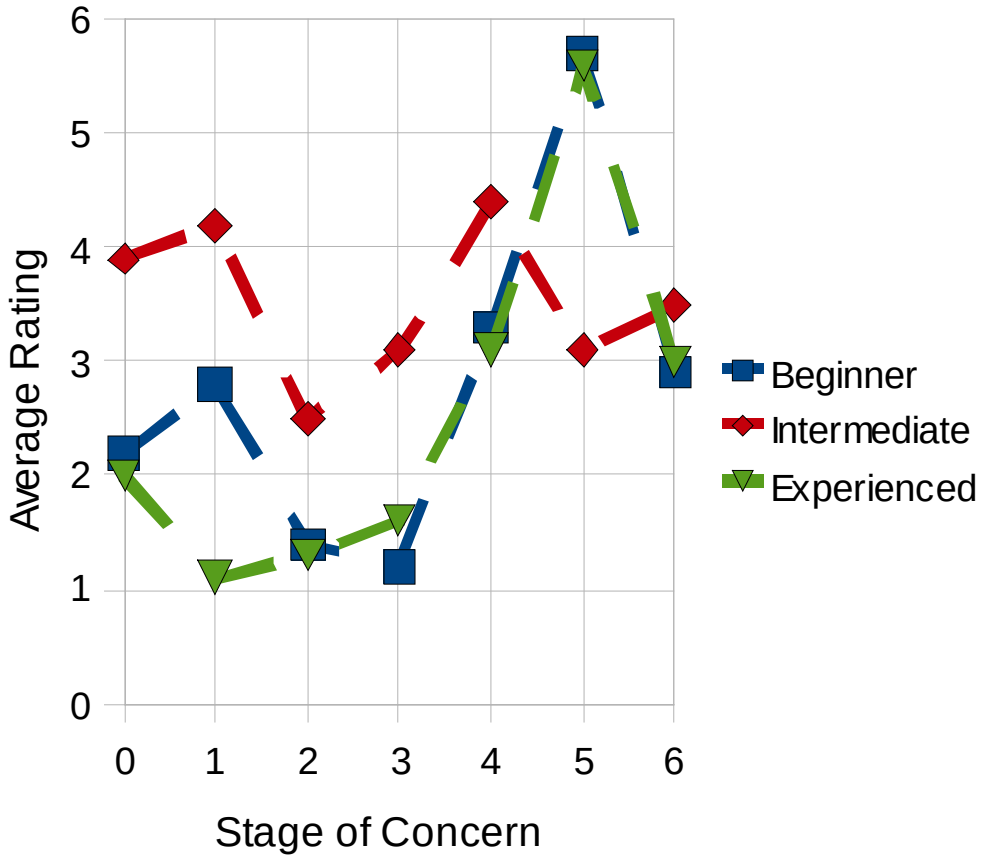

Figure 4. Average Stages of Concern Mean Score by Experience Category.

Table 16 displays the average of the percentile scores of the participants within each experience category. Compared to the average of the mean scores, the biggest difference is that the Intermediate users now collectively peak at "Stage 0 – Awareness." The Beginners and Experienced users still peak at "Stage 5 – Collaboration." Figure 5 presents the same information in Table 16 in line graph form.

Table 16

Average Stages of Concern Percentile Score by Experience Category

Participants	Experience Category	Stage of Concern						
		0	1	2	3	4	5	6
A & B	Beginner	61.5	54	31	19	20	**81.5**	40
C & D	Intermediate	**96.5**	77	49	57	46.5	32	53.5
E & F	Experienced	54.5	28.5	30	27	17	**80**	43.5

Note: The highest average score for each participant is highlighted and typed in bold.

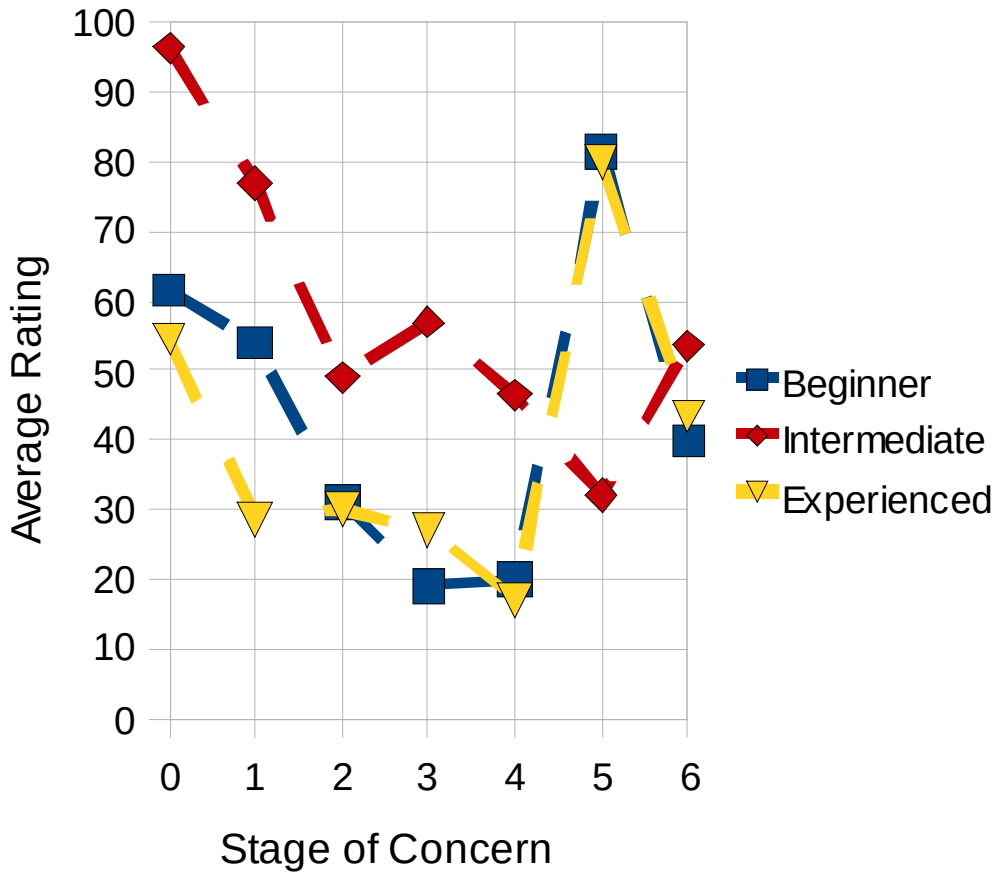

Figure 5. Average Stages of Concern Percentile Score by Experience Category.

Summary

The Stages of Concern Questionnaire yielded interesting results. The Beginner IWB users, both individually and collectively, had mean and percentile scores indicating that they were at "Stage 5 – Collaboration." This was the same Stage as the Experienced IWB users, both individually and collectively. According to George, Hall, and Stiegelbauer (2006), a high Stage 5 score "suggests concerns about working with others in relation to use of the innovation" (p. 54). Participant B, who had never collaborated before in regards to his IWB, had a second peak was at Stage 1, which "suggests a desire to learn from what others know and are doing rather than a concern for leading the collaboration" (George, Hall, & Stiegelbauer, 2006, p. 54).

The Intermediate IWB users were less uniform. Participant C's mean scores peaked at "Stage 4 – Consequence," but her percentile scores were highest at "Stage 0 – Awareness." Participant D's mean and percentile scores both peaked at "Stage 0 – Awareness." Collectively, the Intermediate IWB users' mean score peaked at "Stage 4 – Consequence," but the percentile scores peaked at "Stage 0 – Awareness." A high Stage 0 "indicates a person who is not concerned about the innovation" (George, Hall, & Stiegelbauer, 2006, p. 53).

Research Question Two

What levels of use are indicated by mathematics teachers with differing years of IWB experience?

Following the administration of the Stages of Concern Questionnaire (Appendix A), each participant was interviewed individually using the Level of Use Interview Protocol (Appendix B). The purpose of the LoU interview was to determine which level of use each participant was in relation to their IWB usage in the classroom. A model lesson for each Level of Use, adapted from the guidelines of Hall, Dirksen, and George (2006), is presented in Appendix G. The LoU classifications were used to answer Research Question Two.

The Level of Use Interview Protocol questions were read exactly as written by Hall, Dirksen, and George (2006, pp. 53-54). Prior to the interviews, the participants were informed that the Protocol's use of the phrase "the innovation" referred to the IWB installed in their classroom. Detailed responses to each question from each participant, with some clarifying remarks and discussion from the researcher, are provided in Appendix H. Highlights of their responses and emergent themes are provided next.

LoU Interview Highlights and Themes

Question 1: Are you using the innovation?

All participants answered affirmatively to this question. Their answers were expected since each of the participants was specifically selected because they had IWBs installed in their classrooms. While it is possible that a teacher could avoid using an

installed IWB in their own classroom, all of the participants had previously indicated to the researcher that they did, in fact, use their IWBs to varying degrees.

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

Noted strengths were:

- Increased visibility (Participants A, B, D, E)
- Ability to save class notes (Participant A, D, E, F)
- Ability to post class notes on-line (Participant A, D, E, F)
- Ability to run software programs like Fathom (Participants C, D)
- Ability to pull up documents during class (Participant B)
- Ability to use a virtual graphing calculator (Participant E)
- Faster lessons (Participant C)
- Utility as another available writing surface when it is not installed on an existing whiteboard (Participant A)
- Ability to increase student focus on lessons (Participant B)

Noted weaknesses were:

- Increased planning time (Participants A, F)
- Having to recalibrate the touch-screen whenever the projector was bumped (Participants D, F)
- IWB peripherals (such as Activators) take even more planning (Participant A)
- Amount of knowledge required to use an IWB effectively (Participant B)
- Handwriting with a stylus is not as neat as traditional handwriting (Participant D)

- Students can be intimidated by the technology (Participant E)

Participant C did not name any weaknesses.

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Participants A and B were actively trying to learn more about IWB functionality. Participant C was comfortable with her IWB knowledge and was not looking for any more information. Participant D was not looking for information, but was trying to improve her knowledge and performance with practice on her own. Participant E looked for more information during school breaks in order to find ways to increase student involvement and new IWB techniques. Participant F was satisfied with his IWB knowledge, but wanted to add speakers to his IWB to enhance the experience.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant A talked about lesson planning and sharing of IWB materials with her team teacher. Participant B talked to others to about the advantages and disadvantages of IWB use and tried to learn new techniques. Participant C had told the mathematics department head about the benefits of IWBs. Participant D told others what she liked about using an IWB. Participant E has offered to help others learn how to use IWBs and has invited teachers without IWBs to use her classroom. She has also told teachers how useful it was to be able to save class notes on-line. Participant F has discussed all the different ways IWBs can be used.

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Effects of IWB use included:

- Help for absent students to see missed material (Participant A)
- Faster lessons (Participant B)
- Enhanced lessons (Participant B)
- Improved student motivation (Participant C)
- Enhanced note-taking (Participant E)
- Parents can see what was taught in class (Participant F)

Feedback from students included:

- Students like the IWB (Participant C, E)
- Students think the technology is fun (Participants B, D)
- Students are already used to IWB technology (Participant A)
- Students appreciate the ability to access previous class notes (Participant E)
- Students enjoy writing on the IWB (Participants A, F)
- Some students do not feel comfortable writing on the IWB (Participant E)

Participants A, B, C, D had not completed any formal or informal evaluation of IWB use. Participant C noted the lack of a control group required for her to formally evaluate the effects of IWBs use.

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

The participants mostly answered "no" to this question. Participant B had changed the most since he was still learning new techniques like saving class notes and displaying documents. Participant D had started preparing word-processed notes in class to alleviate her handwriting concern. Participant E said she has figured out better ways to incorporate her virtual graphing calculator into her lessons. The school year before, she had purchased a wireless tablet input device to enable "writing" on the IWB from across the room. Participant F had a chance to move into a new classroom at the beginning of the school year, so he installed his new IWB onto a wall without a whiteboard so he could write on multiple walls.

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

The following plans were mentioned:

- Seek more information about IWB techniques (Participant A)
- Incorporate the IWB more into lessons (Participant A)
- Get students more involved in using the IWB (Participants A, C)
- Use peripherals more in conjunction with IWB (Participant A)
- Using Fathom software more often (Participant D)
- Seek content specific material for IWB use to enhance student learning (Participant E)
- Practice using the IWB's recording functions (Participant F)

- Add speakers to enhance the IWB experience for students (Participant F)

Participant B said he had no plans other than to keep using his IWB.

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

Participants A and F collaborated together with a third teacher who team-taught with Participant A. Participants C and D collaborated together. Participant B was not collaborating with anyone, but wanted to begin doing so. Participant E had collaborated about IWBs in the recent past, but was no longer actively collaborating with anyone. She said she had asked others about collaborating with her, but could not find anyone who was available or had a similar teaching load.

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

All of the participants responded that they were not planning to make any major modifications to their IWB use. Participant E wanted to have her LCD projector installed on her ceiling. None of them wanted to replace their IWB.

LoU Collaboration Questions

Questions 10 through 16 were reserved for those participants who had collaborated or were collaborating at the time of the interview. All of the participants except Participant B responded affirmatively to Question 8, so the last set of questions were asked of them. Participant B was not asked the questions since he indicated in his

response to Question 8 that he did not collaborate with anyone regarding IWB usage in the classroom.

Question 10: How do you work together? How frequently?

Participants A and F said they collaborated together, and Participants C and D said they collaborated together. Each member of these pairings responded that they collaborate on a daily basis, which they attributed to the close proximity to their collaborators and shared course loads. Participants C and D physically shared the same room during fourth period, which was their lunch/study hall period. Without this shared time together, Participants C and D indicated that they would not have collaborated nearly as much.

During their collaboration times, all of the respondents noted that they shared class notes for upcoming lessons for use with their IWB. They also discussed IWB methods that worked well for students and other methods that did not work so well. Their collaborations were a mixture of technical help, preparation assistance, and discussions about improving student and teacher outcomes.

Participant E, who used to collaborate with Participant F and another teacher when she first received her IWB, was not collaborating with anyone at the time of the interview, but was interested in doing so. In her previous collaborative experience, she initially collaborated often, but the meetings and emails became less frequent as she gained experience with her IWB. When one of her collaborators left education to pursue a career in industry, Participant E stopped collaborating all together.

Question 11: What are the strengths and the weaknesses of this collaboration for you?

All of the respondents agreed that one of the strengths of collaborating was a reduction in preparation time. By sharing class notes for upcoming lessons, there was no need for each IWB user to develop their own. Collaborating also cut down on technical problems that might arise when teaching the new lesson, since collaborators could discuss what worked well and what did not. Participant D, who shared her IWB with Participant C, cited the ability to call for technical support if their machine malfunctioned so that her collaborator would be able to use the IWB later in the day.

Among the weaknesses cited, Participant F noted the difficulty of sharing material across IWB brands. The Inspire Edition software used with the Promethean boards was not easily convertible to files that are readable by SMART Boards, so it became more time-consuming to collaborate. Participant E noted that even when users had similar software, their shared lessons had to be tweaked in order to fit a teacher's personal preferences and needs for any given lesson. Participant A could not describe any weaknesses about her IWB collaborations, but she did note that students needed to be open-minded with her unusual team-teaching arrangement. Participants C and D could not identify any weaknesses at all to their collaboration.

Question 12: Are you looking for any particular kind of information in relation to this collaboration?

All of the respondents responded that they were not seeking specific information about IWB collaboration. Participant F said he was more interested in learning how to improve student interaction with IWBs.

Question 13: When you talk to others about your collaboration, what do you share with them?

Participant A told others about her collaboration, "We love it." Participant C told others how valuable it was to share a common classroom and some downtime with her collaborator. Participant D had not spoken to anyone about the collaboration because she worked part-time and rarely saw other teachers. Participant F told others how helpful it was to collaborate with teachers who shared the same students.

Question 14: Have you done any formal or informal evaluation of how your collaboration is working?

Participant A conducted a formal student survey regarding her team teaching arrangement, open classroom environment, and IWB use. She said student responses were mixed. Participant D said she could tell from past AP Statistics exam scores that her collaboration was making her a better teacher. Participant F said he had made informal comparisons of student performance in the different teaching arrangements enabled by his collaboration, but he did not provide any results. No other participant had conducted any formal or informal evaluations about their collaborations.

Question 15: What plans do you have for this collaborative effort in the future?

Participants A, C, D, and F planned to continue their collaborations in the future. Participant E, who was no longer collaborating, wanted to find someone with whom she could collaborate. Participant F wanted to let other teachers experience similar collaborative arrangements as his across the entire mathematics department.

Question 16: Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Participants summarized themselves by saying they:

- Desired to learn more about IWB techniques (Participants A, E)
- Needed more training (Participant D)
- Were comfortable with their IWB skills and knowledge (Participants C, F)
- Felt that IWBs were not likely to improve student achievement (Participant A)
- Felt that IWBs increased student engagement (Participant A)
- Would have difficulty teaching without an IWB again (Participant E)

Level of Use Ratings by Participant

Based on the responses provided by each participant in the LoU Interviews, a rating sheet was used to help determine their level of use by category. These ratings were then used to determine an overall level of use rating for each participant. It was adapted from the Rating Sheet developed by Hall, Dirksen, & George (2006, p. 57). The rating sheets are provided in Appendix I. The ratings were determined according to the

guidelines provided by the same authors. Table 17 graphically depicts the level of use rating for each category and then summarizes with an overall LoU for each participant.

Table 17

Levels of Use Ratings by Participant

Participant A

Category	Rating	Key information used to determine rating
Knowledge	V	Coordinated with colleagues to improve student learning
Acquiring Information	IV B	Sought information about improving student learning
Sharing	V	Shared IWB work to improve student achievement
Assessing	IV B	Assessed student opinions of her IWB usage
Planning	V	Had specific plans to continue collaborating
Status Reporting	V	Gave detailed reports about her collaboration
Performing	V	Worked with colleagues to improve IWB impact on students
Overall LoU	V	Average rating was 4.86, which rounded up to 5

Participant B

Category	Rating	Key information used to determine rating
Knowledge	III	Understood day-to-day requirements for using IWB
Acquiring Information	III	Sought information about improving basic IWB skills
Sharing	III	Shared information about operating IWB better
Assessing	III	Examined his own behavior to improve IWB skills
Planning	IV B	Had plans to improve IWB skills in the future
Status Reporting	IV A	Learned how to manage the “little things” about his IWB
Performing	III	Still learning how to operate IWB effectively
Overall LoU	III	Average rating was 3.38, which rounded down to 3

Participant C

Category	Rating	Key information used to determine rating
Knowledge	IV B	Knew that IWB could be used to help students visualize math
Acquiring Information	IV A	Was not actively seeking information about IWBs
Sharing	V	Shared IWB files to increase student achievement
Assessing	IV A	No formal evaluations of IWB use
Planning	IV A	Did not expect to change IWB use in the future
Status Reporting	IV A	Reported only knowing enough to use the IWB for her intended purposes and did not need anything else
Performing	IV B	Wanted to increase student involvement with IWB
Overall LoU	IV B	Average score was 4.29, which rounded up to 4.5

Participant D

Category	Rating	Key information used to determine rating
Knowledge	IV A	Comfortable using IWB for day-to-day needs
Acquiring Information	IV A	Was not actively seeking information about IWBs
Sharing	V	Shared IWB files to increase student achievement
Assessing	IV A	No formal evaluations of IWB use
Planning	IV A	Did not expect to change IWB use in the future
Status Reporting	III	Desired training to improve IWB skills; described herself as a “novice”
Performing	IV A	Standardized but limited use of IWB
Overall LoU	IV A	Average score was exactly 4

Participant E

Category	Rating	Key information used to determine rating
Knowledge	IV B	Knew how to use IWB in various ways to improve learning
Acquiring Information	IV B	Actively sought IWB information during school breaks
Sharing	IV B	Was willing to share IWB knowledge with others
Assessing	IV A	No formal evaluations of IWB use
Planning	IV B	Planned to keep improving IWB use to benefit learning
Status Reporting	IV B	Reported changes designed to “enhance” learning
Performing	IV B	Has tried multiple ways to teach with the IWB
Overall LoU	IV B	Average score was 4.43, which rounded up to 4.5

Participant F

Category	Rating	Key information used to determine rating
Knowledge	V	Knew how to collaborate regarding IWB use
Acquiring Information	IV A	Was not actively seeking any new IWB information
Sharing	V	Collaborated to improve student learning
Assessing	V	Asked students about IWB and collaboration effects
Planning	V	Planned to continue collaborating and "enhance" his IWB
Status Reporting	V	Collaborated on a daily basis with other IWB users
Performing	V	Worked with others to improve student learning via IWB
Overall LoU	V	Average score was 4.86, which rounded up to 5

Summary

Participants A and F were both rated at Level V, the highest overall LoU among the group. This indicated that collaboration was a significant component of their IWB usage. Participants C and D, who also collaborated on a daily basis, did not rate quite as high since other factors lowered their overall average. For example, Participant D was rated a score of III under Status Reporting since she described herself as a "novice," which helped reduce her overall score to IVA. Participant E, who did not collaborate with anyone anymore, was still scored at IVB overall since she reported using her IWB in a variety of ways to improve student learning. Participant B scored the lowest LoU rating in the group. His overall rating of III indicated an IWB user who was still learning how to use the technology.

In general, it appears that increased IWB experience results in a higher overall LoU. Participant B, a Beginner IWB user, had the lowest rating overall, while Participant F, the most experienced user in the study, had the highest rating. Participant A's high

rating indicates that experience is not the only determinant of LoU, however. Her rating suggests that active collaboration with a more experienced user can dramatically improve the IWB usage of a beginner. Collaboration is not always enough, though. Participants C and D also collaborated, but their similar skill levels did not seem to help either one improve their IWB usage very much. Skill differential is likely important for drastic improvement. Table 18 summarizes the LoU ratings for each of the six participants.

Table 18

Summary of LoU Ratings

Participant Information		Level of Use Categories							
Participant	IWB Experience Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
A	Beginner	V	IVB	V	IVB	V	V	V	V
B	Beginner	III	III	III	III	IVB	IVA	III	III
C	Intermediate	IVB	IVA	IVA	IVA	IVA	IVA	IVB	IVB
D	Intermediate	IVA	IVA	V	IVA	IVA	III	IVA	IVA
E	Experienced	IVB	IVB	IVB	IVA	IVB	IVB	IVB	IVB
F	Experienced	V	IVA	V	V	V	V	V	V

Research Question Three

How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?

After each participant completed the Stages of Concern Questionnaire and Levels of Use interviews, they were asked to choose two lessons to be video-recorded. The only guideline was that the lessons had to be representative of their typical IWB use. To record each lesson, a video-camera was installed in the back of the classroom and focused on the IWB screen. The researcher left the room prior to the start of each lesson, so the participants were instructed to start and stop the recording as they saw fit. They were told that the primary purpose was to record IWB activity, so any part of the lesson that did not involve the IWB did not need to be recorded.

The recordings were analyzed using the Glover, Miller, Averis, and Door (2007) guidelines by the primary researcher and an assistant. The analyses were conducted independently, but were then discussed and merged into one rating for each lesson for each teacher. An overall rating for each participant was then created by merging the ratings of their two lessons. The two researchers generally agreed with each other in their classifications of each lesson. Differences were relatively minor, affecting individual categories rather than overall lesson classifications. Inter-rater reliability can therefore be considered high.

An in-depth discussion of the lessons, with screen-captured photos and analyses, is presented in Appendix K. The Experienced users generally displayed the most Enhanced Interactivity, though Participant A displayed similar characteristics. Participant

B and the Intermediate users generally displayed Interactive characteristics. Table 19 summarizes the GMAD classifications for each category and lesson by each participant.

Table 19

GMAD Classifications by Participant

Participant A

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Engagement	Interactive	Enhanced Interactivity	Enhanced Interactivity
Social Context	Interactive	Interactive	Interactive
Technology	Interactive	Enhanced Interactivity	Enhanced Interactivity
Overall	Interactive	Enhanced Interactivity	Enhanced Interactivity

Participant B

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy	Supported Didactic	Interactive	Interactive
Engagement	Interactive	Interactive	Interactive
Social Context	Supported Didactic	Interactive	Interactive
Technology	Supported Didactic	Interactive	Interactive
Overall	Supported Didactic	Interactive	Interactive

Participant C

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy	Interactive	Supported Didactic	Interactive
Engagement	Interactive	Supported Didactic	Interactive
Social Context	Interactive	Supported Didactic	Interactive
Technology	Interactive	Interactive	Interactive
Overall	Interactive	Supported Didactic	Interactive

Participant D

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy	Supported Didactic	Interactive	Interactive
Engagement	Interactive	Interactive	Interactive
Social Context	Interactive	Interactive	Interactive
Technology	Supported Didactic	Interactive	Interactive
Overall	Supported Didactic	Interactive	Interactive

Participant E

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Engagement	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Social Context	Interactive	Interactive	Interactive
Technology	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Overall	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity

Participant F

Category	GMAD Classification		
	Lesson One	Lesson Two	Overall
Pedagogy	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Engagement	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Social Context	Interactive	Interactive	Interactive
Technology	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
Overall	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity

After each participant had two IWB lessons video-recorded and analyzed, the IWB Teacher Follow-Up Questions (Appendix D) were asked. The overall interview was relatively quick for each participant, averaging approximately three minutes each. A synopsis of all of the participant responses is presented in Appendix L. Overall, the responses to the IWB Teacher Follow-Up Questions supported the classifications obtained from the video-recording analyses.

Summary

The video-recorded lessons, the resulting GMAD classifications, and the IWB Teacher Follow-Up Questions were used to answer Research Question 3. Table 20 summarizes the GMAD classifications by participant. The overall classification for each participant was determined to be the higher of the two lesson classifications.

Table 20

Summary of GMAD Video-Recorded Lesson Classifications

Participant	IWB Experience	Lesson One	Lesson Two	Overall
A	Beginner	Interactive	Enhanced Interactivity	Enhanced Interactivity
B	Beginner	Supported Didactic	Interactive	Interactive
C	Intermediate	Interactive	Supported Didactic	Interactive
D	Intermediate	Supported Didactic	Interactive	Interactive
E	Experienced	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity
F	Experienced	Enhanced Interactivity	Enhanced Interactivity	Enhanced Interactivity

As Table 20 illustrates, IWB experience had some effect on classroom behavior. Participants with less experience generally conducted their lessons at the Supported Didactic or Interactive level, while the experienced users exhibited Enhanced Interactivity lessons. The lone exception was Participant A, who conducted one of her lessons at the Enhanced Interactivity level. Her collaborative efforts with Participant F and her team teacher were likely the reason for this.

Research Question Four

Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

The data suggest that there is a strong relationship between IWB concerns, levels of use, and actual implementation. In general, the most experienced users demonstrated higher stages of concern, levels of use, and implementation skill. The only notable exception was Participant A, whose collaboration with Participant F helped her think and perform like a much more experienced user. Table 21 presents a summary of the data.

Table 21

Summary of Research

Participant	IWB Experience	Peak Stage of Concern	Overall Level of Use	Overall GMAD Classification
A	Beginner	5	V	Enhanced Interactivity
B	Beginner	5	III	Interactive
C	Intermediate	0	IV B	Interactive
D	Intermediate	0	IV A	Interactive
E	Experienced	5	IV B	Enhanced Interactivity
F	Experienced	5	V	Enhanced Interactivity

Stages of Concern

The results from the Stages of Concern Questionnaire were somewhat unexpected in that the Beginner IWB users were at a higher reported stage of concern than the Intermediate IWB users. The Beginners were even on par with the Experienced users in terms of their concerns. This finding could be attributed to a variety of factors: the collaboration of Participant A with Participant F, Participant C's “floating” classroom, and the half-time nature of Participant D's employment.

The collaboration between Participants A and F had been very helpful for Participant A for numerous reasons. First, the two teachers were located right next door to each other, which facilitated collaboration. Second, the two teachers shared a similar course load, so they had a compelling reason to collaborate on a daily basis. Third, Participant F had been using an IWB longer than anyone else in the school, so he had experience helping new IWB users and considered himself an “expert” user. His pairing

with Participant A helped her excel so quickly in her IWB understanding that her concerns mimicked those of much more experienced IWB users rather than the other Beginner IWB user.

The other two factors are related: Participant C's “floating” classroom and Participant D's half-time employment. Participant D, who had the lowest reported Stage of Concern among all the participants in this study, only taught three classes a day. Although Participant D was classified as an Intermediate IWB user since she had been using her IWB for more than a full school year at the time of the study, this characterization appears to be misleading since she had only been using her IWB for less than four periods a day. In contrast, a full-time teacher with all day IWB access is able to use the innovation for five or more periods a day. Therefore, a half-time teacher has approximately half of the hands-on IWB experience as a full-time teacher over a given time period. By this accounting, Participant D might be better classified as a Beginner IWB user instead. Such full-time/half-time status should be taken into account in future studies of innovation implementation.

Participant C, who shared a classroom with Participant D, was in a similar situation. Using a raw average score, she appeared to be at Stage of Concern 4, but the percentile score signifying relative intensity indicated that she was at Stage 0. Although she was a full-time teacher, she had to “float” to different, unoccupied classrooms while Participant D is teaching in her room. Since there were only eight IWBs installed in the school, Participant D usually taught in a classroom without an IWB. Therefore, she only had the same potential for hands-on IWB experience as a half-time teacher. The relative

lack of hands-on experience was clearly a factor in the concerns of IWB users since both Participants C and D reported being at a lower Stage of Concern than the Beginner and Experienced users in this study who all had full-time access to their IWBs.

Another unusual finding of the Stages of Concern Questionnaire was Participant B's relatively high level of concern. As a Beginner who did not collaborate with other IWB users, he was expected to show more concern about the mechanical aspects of using his IWB. Instead, his desire to collaborate with other IWB users was an overriding concern for him. As his responses to the following LoU interviews detailed, Participant B was still learning the mechanics of using his IWB, but he was not so much concerned about learning the mechanics as he was concerned with finding collaborators with whom he could work.

Level of Use

The LoU determinations were more in line with what was expected based on experience classifications with the single notable exception of Participant A. Similar to the conclusions drawn from the Stages of Concern Questionnaire, Participant A's reported level of use with her IWB is comparable to that of much more experienced IWB users. Her daily collaboration with her team teacher and Participant F is the most likely reason for this. The other Beginner, Participant B, was determined to be at a much lower level of use than Participant A even though they have had their IWBs for the same amount of time. Since Participant B was not collaborating with anyone, it appears that collaboration about IWBs can improve reported levels of use by at least three levels.

Another notable conclusion to the LoU ratings was that Participants C and D, despite their limited hands-on experience with IWBs compared to teachers with full-time IWB access, were at least comfortable in their use of IWBs. They both described themselves as being competent with IWBs but not very interested in expanding or improving their understanding of the innovation. Perhaps more opportunity for hands-on experience is a necessary component for further professional growth.

Video-recorded lessons

The video-recorded lessons indicated once again that Participant A's collaboration with Participant F had helped make her IWB lessons comparable to an Experienced user's. She was the only non-Experienced participant to have a lesson classified at the Enhanced Interactivity level. The other three non-Experienced participants each had one lesson that was Supported Didactic and one that was Interactive.

The conclusion is that experience with IWBs can help teachers conduct more interactive lessons taking fuller advantage of the technology's capabilities. Collaborating with an experienced user can hasten the process so that a Beginner can prepare Enhanced Interactivity lessons, as well. It should be noted, however, that collaboration alone does not make a user able to conduct Enhanced Interactivity lessons. Participants C and D were engaged in collaboration with each other, but their lessons did not demonstrate a high degree of IWB knowledge or interaction. This was perhaps due to their limited exposure to their IWB each day compared to teachers who could use their IWBs all day.

IWB Teacher Follow-Up Questions

The follow-up questions succeeded in establishing the validity of the video-recorded lessons. Each participant replied that the video-recorded lessons were representative of their typical IWB usage, so the GMAD classifications given to those lessons could be applied to each participant's lessons in general. No comments were made that would have changed a given GMAD classification of a participant.

The comments from the participants about their IWB pedagogical strategies were illuminating. None of the teachers responded with typical constructivist terms, but many indicated that they tried to get students involved and actively engaged with the IWB. As the video-recordings demonstrated, it was common for participants of all experience levels to invite students to use the IWB during class. It was unclear if the participants would have invited similar student participation with a whiteboard or if the IWB itself was the motivation.

The follow-up question regarding IWB concerns was intended to support the Stages of Concern Questionnaire. While responses to this question provided some information about participant concerns, the responses did little to support or detract from the scores derived from the Stages of Concern Questionnaire. One thing was made clear by this question, however: the participants definitely wanted their IWB's LCD projector installed on the ceiling to avoid the hassle of recalibration.

One final notable outcome of the responses to the follow-up questions was the approval of IWBs given by most of the participants in response to the sixth question, “Do you have any other comments about IWBs?” Many participants responded that they

"love" having an IWB and would not want to teach without one. This could be an important factor in purchasing and maintaining IWBs in classrooms, regardless of how much student learning actually improves as a result of the technology.

Summary

Given the results of the Stages of Concern Questionnaire, the Levels of Use interview, and the GMAD classifications of the video-recorded lessons, the relationships between these are somewhat strong. The most experienced users were at the highest Stage of Concern among the participants in this study and consistently exhibited the best use of IWBs in their lessons. Participant E was judged to be at a lower Level of Use since she no longer collaborated with other IWB users, but her skill with the technology was demonstrably great.

The Intermediate users, while technically defined as having more experience than the Beginners, scored a lesser Stage of Concern than all other participants. Their LoU and GMAD classifications were also on the lower end among the participants. This was likely due to the part-time nature of their IWB use: Participant C only worked half-days while Participant D floated to other classrooms without IWBs installed. Therefore, while they technically had more than 1 year of IWB experience at the time of this study, they did not really have full day access to IWBs over that time. In addition, the two Intermediate users collaborated on a daily basis, but since they had similar IWB knowledge and skill, they appeared to gain little benefit from their collaboration. As a

result, the two Intermediate users appeared to be comfortable in their IWB use but did not wish to expand their knowledge or skill with the IWB beyond their present level.

The Beginner users were at different ends of the spectrum. Participant A, with her daily collaborations with Participant F and her team teacher, exhibited the exact same scores and classifications as her more experienced collaborator. Participant B, who did not collaborate at all, was judged to be at the lowest LoU and GMAD classification among the participants. Perhaps not surprisingly, his Stage of Concern was high, indicating his strong desire to collaborate with others. Unlike the Intermediate users, Participant B had access to his IWB all day long and wanted to learn how to improve his skill with it. It was clear that he recognized the benefits of collaboration.

Summary

The results of the different instruments used in this study were occasionally surprising, but a consistent picture did eventually emerge of each participant. Overall, the results showed that the amount of IWB experience does influence teacher concerns and classroom performance, but full-day IWB access and productive collaborations were also important. A beginner IWB user who collaborates with an experienced user and has access to an IWB all day will likely progress more rapidly than a non-collaborating IWB user. Users who do not collaborate with more experienced users or do not have full-day access to an IWB will eventually become competent with the technology, but their abilities and knowledge will stagnate, leaving the great promise of IWB technology unfulfilled in their classrooms.

CHAPTER FIVE

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

"'The future is already here. It is just not uniformly distributed."
— William Gibson (Quoted in Buxton, 2004, ¶ 3)

William Gibson's quote nicely encapsulates the current state of IWB use in classrooms. IWBs represent a technology that can enable enriched mathematical instruction right now, yet they are only installed in a handful of classrooms across the world. This is due to a number of reasons: lack of funding, lack of desire, lack of training, and lack of knowledge. In addition, as the findings in Chapter Four illustrated, the skills required to utilize IWBs effectively are unevenly distributed amongst teachers. The implications of these findings must be further explored.

This final chapter will discuss the findings of the study and how they relate to existing research as well as to the research questions of this study. It will also summarize findings about the participants and provide overall thoughts on the outcome of the study. Finally, it will discuss the implications of the findings and how they can guide future research.

Research Questions

The primary research question of this study was, "How do mathematics teachers with varying years of IWB experience differ in their implementation of IWBs?" In order to answer this question more completely, it was broken down into four discrete parts:

1. What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?

2. What levels of use are indicated by mathematics teachers with differing years of IWB experience?
3. How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?
4. Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

Research Question One: What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?

The two Beginner users and two Experienced users in this study registered similar Stages of Concern. Collaboration was the main concern for all four, but only two of them were currently collaborating. Participants A and F were collaborating together, so their SoC results reflected their interest and focus. Participants B and E, on the other hand, were not collaborating with any other IWB users, but their high Stage 5 ratings indicated their desire to collaborate. Therefore, although all four participants peaked at Stage 5, there was a difference between the Have's and the Have-Not's in terms of collaboration.

The two Intermediate users registered the lowest stage concerns. Both peaked at Stage 0, the Awareness stage. Other, smaller peaks occurred at Stages 3 and 4, the Management and Consequence stages. This suggested that the Intermediate users were both still becoming comfortable with IWBs, but were not very interested in doing so. Resistance to growth is not uncommon among individuals faced with change (Slough,

1999). In the case of Participants C and D, their resistance was likely due to their part-time exposure to the technology, which reduced the benefits of improving their IWB use.

Research Question Two: What levels of use are indicated by mathematics teachers with differing years of IWB experience?

Participants A and F had the highest LoU ratings: Level V. While the most experienced user in the study would be expected to register the highest LoU, it was noteworthy that one of the Beginner IWB users rated as highly as an Experienced user. This was due largely to their active collaboration on a daily basis. This suggested that collaboration with a better-skilled IWB user can help a beginner perform like a much more experienced user. Both participants had also received formal training early in their IWB training, which supported the importance of professional development.

Participant B had the lowest LoU: Level III. This was likely due to his status as a Beginner IWB user that had never received any formal training and worked without a collaborator. His low rating also supported the need for collaboration and professional development.

Participants C, D, and E were rated at Level IV A and IV B, in between the other participants. Participants C and D collaborated together, but they were similarly skilled with their IWBs, so their collaboration did not seem to yield as much improvement as Participant A's collaboration. In addition, they only had access to their IWB for half of each school day, so their limited exposure to the technology appeared to hamper their growth. Neither had received any formal training either. In contrast, Participant E has

received formal IWB training, but she no longer collaborated with anyone. This caused her to be rated below Level V, which requires active collaboration.

Research Question Three: How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?

Participants A, E, and F demonstrated Enhanced Interactivity lessons, the highest level in the GMAD classification system. For Participants E and F, their high performance was credited to their full-time IWB experience over multiple years, past collaboration efforts, and early professional development. For Participant A, her high performance was credited to her collaboration with an Experienced user and her ongoing professional development.

Participants B, C, and D demonstrated Interactive lessons, the middle level in the GMAD classification system. For Participants C and D, their average performance was credited to the following factors: part-time IWB use, lack of formal training, and collaboration between similarly-skilled users. For Participant B, his average performance was credited to a lack of formal training, lack of collaboration partner, and limited IWB experience.

Research Question Four: Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

Based on the data obtained in this study, there appeared to be a strong relationship between IWB Concerns, Levels of Use, and actual implementation. Compared to less experienced users, the Experienced users demonstrated higher Stages of Concern, Levels

of Use, and GMAD Classifications. The lone exception was Participant A, who performed like an Experienced IWB user by all measures.

This finding suggested a variety of ways to improve IWB performance. First, IWB experience matters. In general, the more time that a user spends with an IWB, the better the user will perform. Similarly, full-time IWB users will also outperform part-time users. Second, collaboration is helpful for improving performance, especially if there is a skill differential between collaborators. Beginner IWB users can perform like a much more experienced users if they collaborate with an expert. However, IWB users of similar skill may derive less benefit from their collaboration. Third, professional development matters. The higher performing IWB users in this study had all received preliminary professional development, while the lower performing IWB users had not received any professional development. Finally, room configuration is a significant concern. Many users wanted their IWB's LCD projector on the ceiling to alleviate the hassle of recalibrating the touch-screen. Configuring the room and the IWB to minimize hassles is vital for encouraging time-strapped teachers to implement this technology.

Conclusions

The findings of this study indicated that IWB experience levels have some impact on teacher concerns, levels of use, and implementation. Experience level was not the only factor that influenced these characteristics, however. Other pertinent factors included collaboration, IWB configurations, and the amount of daily contact time that a teacher had with their IWBs.

Collaboration with an expert user has previously been shown to be important in the development of IWB skills. Miller and Glover (2007) asserted that "a school expert is more likely to prompt the more effective development of IWB use" (p. 328). The successful collaboration between Participant A and F supports this assertion. Participant A clearly benefited from her collaboration with an Experienced and self-professed "expert" IWB user. In contrast, Participants C and D also collaborated on a daily basis, but since they shared a similar skill and experience level, the benefits of their collaboration were not as pronounced. Collaboration with an "expert" user appears to be more important than experience level alone as defined in this study.

IWB room configurations were also found to be important. Although the participants were mostly positive about their IWBs, their most common complaint involved the configuration of the IWB's LCD projector in their rooms. In most participant rooms, the LCD projector sat on a desk or rolling cart. Every time it was bumped by a teacher or student, the IWB touch-screen had to be recalibrated. Fixed installations of the LCD projector (i.e., installed on the ceiling or one-piece units like the Promethean board in this study) would alleviate this problem, but budget constraints reportedly did not permit such installations. Thus, the most common complaint associated with IWBs was not the fault of the technology itself, but due to the school's budgetary decisions. This finding seems to be unique in the IWB literature.

Daily contact time with IWBs also appeared to be an important factor. Participants C and D were both classified as Intermediate IWB users since they each had between one and two years of IWB experience, but this classification ignored the fact that

both teachers only had access to their IWBs for half of every school day. Participant C "floated" between classrooms and only had access to an IWB for three periods a day. Similarly, Participant D also had access to an IWB for three periods a day since she was a part-time teacher. This limited contact with IWBs appeared to impact their concerns, levels of use, and implementation. Limited contact time with IWBs combined with other distracters (e.g., "floating" or part-time teaching) appears to increase management stage concerns. This finding is also unique to the IWB literature.

Beyond these conclusions, there are other findings in this study that support the existing IWB literature to varying degrees. These include the attachment that teachers have towards their IWBs, the course of IWB skill development, and the need for professional development. While the body of IWB literature is still nascent, the validity of these findings appears to be strong.

The findings of this study support the notion that teachers enjoy having an IWB in their rooms. Similar to Solvie's (2004) claim, some of the participants in this study indicated that the IWB had become practically indispensible in their teaching. One Beginner IWB user, Participant B, said "it would be tough to go without one." Participant E, an Experienced IWB user, said "I don't know how I would be able to go to a classroom without one." All of the participants planned to continue using their IWB and did not want to stop using the technology. While the benefits of IWBs are still debatable, teachers clearly prefer having the technology in their classrooms.

This study also supports the finding that IWB skills develop along a predictable path. Beauchamp & Parkinson (2005) found that beginner IWB users initially used their

IWBs as simple replacements of previous technologies such as whiteboards and overhead projectors, but they eventually began to utilize the unique and expanded capabilities of IWBs once their comfort and experience with the technology increased. The participants in this study indicated a similar growth curve—the Experienced IWB users generally did more with their IWBs than the less experienced users. The exception was Participant A, who was a Beginner IWB user but demonstrated a skill level similar to the most experienced user in the study. This was most likely due to her daily collaborations with other IWB users, including the most experienced IWB user at the school, Participant F. Thus, while skills predictably develop over time, collaboration can hasten the process.

Professional development was also found to be important in building IWB skills. The best-performing IWB users (Participants A, E and F) had all received some form of IWB training. They had attended IWB workshops in the summer or had worked with an IWB sales representative during the school year. All commented that the training was beneficial. In contrast, Participants B, C, and D had little to no formal training. The GMAD classifications between trained and non-trained IWB users indicate that professional development is important. This supports Tanner and Jones' (2007) finding that teachers need training in order to successfully implement interactive lesson plans and facilitate student learning. It also supports the Hennessey, Ruthven, and Brindley (2005) study which found that untrained IWB users continue using the same pedagogical methods of the past despite the opportunities provided by the new technology.

Implications

Implications for Theory

Based on the data from the Stages of Concern Questionnaires, the Levels of Use interviews, the video-recorded lessons, and the follow-up interviews, there are several implications that can be surmised about IWBs. First, collaboration regarding IWBs is valuable, particularly for new users. As Participant A showed, collaboration between a beginner and experienced IWB user can quickly improve the capabilities of beginners to those approaching much more experienced users. Without collaboration with an experienced user, as Participant B demonstrated, technical and mechanical issues linger longer and slow the progression into higher levels of use.

Second, collaboration is desirable. Four out of the six participants said that they collaborated every day, while the other two said that they would like to collaborate with others. Thus, administrators and department heads should try to create the conditions necessary for frequent collaboration. Based on the participant responses to the LoU Interview Protocol, the conditions include putting teachers in close proximity to other IWB users who share a common course load.

Third, hands-on experience with IWBs is important. Participants C and D, while technically considered Intermediate IWB users according to the definitions set forth in this study, actually reported a lower stage of concern than the Beginner IWB users. This was likely due to their relatively limited hands-on experience with an IWB. Participant D was a half-time employee who only taught three classes a day, while Participant C "floated" for half of every school day and was only able to use her IWB when Participant

D was not teaching in their shared room. As a result, their levels of use were determined to be lower than Participant A's, who was a Beginner IWB user with less than one year of IWB experience. Thus, to improve levels of use, it is vitally important to increase an educator's actual hands-on experience with an IWB.

Fourth, proper IWB preparation takes significant amounts of time. Many of the participants mentioned preparation time as an issue of concern with their IWBs. Participant F, who had been using his IWB the longest of anyone at the school, repeatedly mentioned planning time in his interview. Despite his expertise with the technology, creating new lessons still took him time. Participant E, the second longest user, also reported the need to spend time searching for activities to use on her IWB. Fortunately, collaboration can help decrease the overall time spent preparing lessons, and once lessons are created and saved electronically, they can be used again in the future.

Fifth, IWB configurations in rooms matters. One of the frequent complaints among the participants, including the two involved in the pilot study, concerned the need to recalibrate the IWB every time the LCD projector got bumped. With the exception of Participant A, whose Promethean board came with an LCD projector attached to an arm extending from the top of the board, all of the participants had their LCD projectors sitting on tables, desks, or carts near the middle of their classrooms. Such a layout, while largely unavoidable, practically assures that the LCD projector will get bumped by the teacher or students. It would be far better to install the LCD projector on the ceiling to minimize this effect. Unfortunately, such installation costs money that this school could not, or did not want, to pay. Considering the overall cost of IWBs and the hassle of

frequently recalibrating them, it is likely worth the expense to fund the ceiling installation. Otherwise, the end result could be like the Beginner user in the pilot study, who simply disabled the touch-screen capability of his IWB rather than deal with the recalibration issue. Without its touch-screen capability, an IWB system is little more than an LCD projector and a screen, a pair that would be considerably cheaper than purchasing a full IWB system. To encourage teachers to fully implement their IWBs, the LCD should be mounted on the ceiling or otherwise removed from routine human contact.

Sixth, professional development is important. Participants A, E, and F had all received some initial professional development, while Participants B, C, and D had not received any professional development. The latter participants' LoU ratings and GMAD classifications were generally lower than previous participants, so professional development appears to have an impact on IWB use. Once initial training had been received, Participants A, E, and F were comfortable learning more about their IWBs on their own or with collaborators. Thus, initial IWB professional development is likely all that is required for long-term growth and progress.

In summary, the implications of this study apply to various stakeholders in education. They include teachers, professional developers, administrators, and teacher educators. Each has a unique and complementary role in ensuring that the technology is used as beneficially as possible. The following are the key points that each stakeholder should consider when implementing IWBs in the classroom.

Implications for Practice

Teachers

- IWBs can be used to enhance lessons beyond anything previously possible. Seek training and collaborate with more experienced users in order to learn how.
- Try to gain as much experience as possible with an IWB. In general, more time spent with the technology equals better performance in the classroom.

Professional Developers

- IWB training is important, particularly when an IWB user first gains access to a board. Otherwise, skill development is slower compared to trained users.
- Beginner IWB users should be encouraged to collaborate with the most experienced IWB users in the school since their skills are quickly shared.

Administrators

- IWB configurations influence teacher performance. The IWB's LCD projector should be installed on a ceiling to minimize recalibration issues.
- Teachers should have full-day access to their IWBs. "Floating" teachers or part-time teachers with minimal IWB contact cannot improve their skills as easily.
- Arrange teaching schedules and room locations to encourage IWB users to collaborate. Teachers, including IWB users, are more likely to collaborate if they share a similar teaching load and are physically located near each other.

Teacher Educators

- There are new pedagogical methods that take advantage of the unique capabilities of IWBs, such as using software (e.g., Fathom, Geometer's Sketchpad) to

illustrate mathematical content and allowing students to manipulate the software themselves in front of the whole class. These methods should be discussed in teacher education programs due to the increasing prevalence of IWBs in classrooms.

- For student teaching assignments, try to place student teachers in classrooms with IWBs if possible. This will provide student teachers with the opportunity to practice IWB skills in a real-world teaching environment with a (likely) more experienced IWB user.
- Technology is not a substitute for good teaching, but it can certainly help. Even veteran teachers prefer having an IWB to not having the technology at all.

Recommendations for Future Research

The findings of this study provided an in-depth analysis of the concerns and behavior of IWB users in the mathematics department at a single high school. The unique findings of this study include the importance of IWB room configurations and full-day contact with an IWB. While the findings of this study have potentially broader applications beyond simply analyzing similar IWB users as those studied here, more research can and should still be done. The findings of this study suggest avenues of future research that could provide even more information about IWB usage.

One way to build on this study is to examine IWB use with a longitudinal study. The data collected in this study occurred over the span of two months, from the Stages of Concern Questionnaire (Appendix A) to the two video-recorded lessons to the IWB Teacher Follow-Up Questions (Appendix D). The data essentially provided a snapshot of

the concerns and behavior of three different classifications of IWB users: Beginner, Intermediate, and Experienced. It would be illuminating to continue this research over a longer period of time, periodically re-administering the Questionnaires, recording new lessons, and repeating the interviews. That way, any changes in the concerns and behaviors of the IWB users could be identified and examined.

Another way to build on this study is to increase the number of subjects involved. This study was necessarily limited to six teachers due to the limited number of IWB users at the research site. Expanding the number of subjects will likely demonstrate that the concerns, levels of use, and skills of IWB users progress more gradually as experience levels increase.

Some possible research questions for such a study could include:

1. How do the concerns of Beginner, Intermediate, and Experienced IWB users change over time?
2. How does the behavior of Beginner, Intermediate, and Experienced IWB users change over time?
3. Is there a point in time where IWB concerns and behavior do not change any more?

Another suggestion for future research would be to conduct this same study at multiple schools. This study was conducted at a large, suburban school in the Southeastern United States. It would be interesting to see if similar results are obtained in different types of schools or in other locales. If not, why not? What causes the differences in IWB concerns and usage?

Another option would be to expand this study beyond a high school mathematics department. This study focused only on users in a mathematics department for a number of reasons. First, it provided a singular focus to the study, a chance to analyze in-depth nearly all the IWB users at a single site. There were only nine teachers at the school with IWBs at the time that the research was conducted. Eight of the nine teachers were studied, either in the pilot study or full-scale study, and the ninth shared her classroom with Participant A on a daily basis, so essentially every IWB user was studied. This allowed a nearly complete analysis of a single school's IWB use. Second, it was also done out of necessity since only mathematics teachers had IWBs at the research site. At the school, IWBs were funded with departmental money, so unless a department wanted to purchase IWBs, they were not purchased. The mathematics department at the school was the only department that wanted IWBs, so no other department had them. Third, mathematics education was the primary research interest for the researcher, so it was natural that this study focused on the mathematics department. Future studies could expand the focus of this research and study IWB concerns and usage in other disciplines and departments.

Finally, the study could be expanded to consider staff development ideas that could help teachers change faster and more deliberately from novice IWB users to experts. As Participant A demonstrated in this study, it is possible for a new IWB user to exhibit expertise far beyond an expected level of behavior or concern. Her remarkable skill was due, in part, to her collaborations with an experienced IWB user. Could other

forms of professional development match or better this outcome, or is collaboration the best way to build expertise?

Summary

This study was interested in answering the question "How do mathematics teachers with varying years of IWB experience differ in their implementation of IWBs?" In order to answer this question more completely, it was broken down into four parts:

1. What stages of concern do mathematics teachers with differing years of IWB experience have about IWB use?
2. What levels of use are indicated by mathematics teachers with differing years of IWB experience?
3. How does classroom teaching with IWBs compare among mathematics teachers with differing years of IWB experience?
4. Are there relationships between mathematics teachers' IWB concerns, levels of use, and actual implementation?

The theoretical frameworks used to approach the question were constructivism and change theory. Constructivism plays a role in IWB usage in two ways: from a teacher perspective and from a student perspective. First, from a teacher perspective, the teacher must construct their own knowledge about how to use an IWB before it can used in a classroom. The participants in this study demonstrated the benefits of both individual and social learning development. Second, from a student perspective, the IWB can become a constructivist teaching tool if used properly. This study demonstrated that expert IWB users are more likely to employ constructivist teaching methods than

beginner IWB users. Therefore, since the constructivist teaching style is preferable for mathematics education, it would behoove administrators, teachers, and other education stakeholders to develop IWB skills in teachers as quickly as possible.

Change theory was also a theoretical framework for this study because it provided a way to view and understand IWB skill development in teachers. The Concerns Based Adoption Model was selected as the best means of analyzing both teacher concerns and levels of use. The data obtained from these instruments indicated that more experienced users do use their IWBs differently than less experienced users, but collaboration can help a relatively new user implement an IWB almost as effectively as an expert user. Thus, increasing collaboration between beginner and experienced users should be the goal of every stakeholder interested in improving the educational outcome of IWBs in the classroom.

References

Anderson, S. E. (1997). Understanding teacher change: Revisiting the Concerns Based Adoption Model. *Curriculum Inquiry, 27*(3), 331-367.

Appelbaum, P. M. (1995). *Popular culture, educational discourse, and mathematics.* Albany, NY: State University of New York Press.

Ball, B. (2003). Teaching and learning mathematics with an interactive whiteboard. *Micromath, 19*(1), 4–7.

Bargal, D., Gold, M., & Lewin, M. (1993). Introduction: The heritage of Kurt Lewin. *Journal of Social Issues, 48*(2), 3-13.

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

Beeland, W. D., Jr. (n.d.). Student engagement, visual learning and technology: Can interactive whiteboards help? Retrieved March 25th, 2009, from http://www.myteacherpages.com/webpages/E2T2grant/files/beeland_am.pdf

British Educational Communications and Technology Agency (Becta). (2003a). The benefits of an interactive whiteboard. Retrieved March 14th, 2009, from http://schools.becta.org.uk/index.php?section=tl&catcode=ss_tl_use_02&rid=86

British Educational Communications and Technology Agency (Becta). (2003b). What the research says about interactive whiteboards. Retrieved March 20th, 2009, from http://partners.becta.org.uk/page_documents/research/wtrs_whiteboards.pdf

Buxton, B. (2004, October 11th). Forward into the past [Electronic version]. *Time.* Retrieved February 7th, 2010, from http://www.time.com/time/magazine/article/0,9171,995340,00.html

Cantor, J. A. (1982). *A verification of Hall's 3-dimensional model through application to a curriculum innovation involving Florida's community/junior college automotive instructors (Doctoral dissertation).* Available from ProQuest Digital Dissertations database. (Publication No. AAT 8218632).

Chamblee, G. E., & Slough, S. W. (2002). Implementing technology in secondary science and mathematics classrooms: Is the implementation process the same for both disciplines? *Journal of Computers in Mathematics and Science Teaching, 21*(1), 3-15.

Chamblee, G. & Slough, S. (2004). Using the Concerns-Based Adoption Model to Assess Changes in Technology Implementation. In R. Ferdig, et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2004* (pp. 864-871). Chesapeake, VA: AACE.

Cobb, P., Perlwitz, M., & Underwood-Gregg, D. (1998). Individual construction, mathematical acculturation, and the classroom community. In M. Larochelle, N. Bednarz, & J. Garrison (Eds.), *Constructivism and education* (pp. 63-80). New York: Cambridge University Press.

Cobb, P. (2005). Where is the mind? A coordination of sociocultural and cognitive constructivist perspectives. In C. T. Fosnot (Ed.), *Constructivism: Theory, Perspectives, and Practice* (2nd ed.) (pp. 39-57). New York: Teachers College Press.

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* Upper Saddle River, NJ: Pearson Education, Inc.

Davis, B. (1996). *Teaching mathematics: Toward a sound alternative.* New York: Garland Publishing.

Dirksen, D. J. (1998). *A statewide evaluation of technology integration by K12 teachers in the state of Idaho.* Boise, ID: Idaho Department of Education.

Dominguez, D., Tunmer, W. E., & Jackson, S. L. (1980). *Measuring degree of implementation of bilingual education programs: Implications for staff development and program evaluation*. Austin, TX: SEDL. (ERIC Document Reproduction Service No. ED 207993).

Dyson, F. J. (2004). *Infinite in all directions: Gifford lectures given at Aberdeen, Scotland, April – November 1985*. New York: Harper & Row.

Elliot, J. (2004). Multimethod approaches in educational research. *International Journal of Disability, Development, and Education, 51*(2), 135-149.

Fosnot, C. T. & Perry, R. S. (2005). Constructivism: A psychological theory of learning. In C. T. Fosnot (Ed.), *Constructivism: Theory, Perspectives, and Practice (2nd ed.)* (pp. 8-38). New York: Teachers College Press.

Francq, G. E. (1983). *Assessment of implementation of science – A process approach II (SAPA II) in selected fourth, fifth, and sixth grade classrooms (Doctoral dissertation).* Available from ProQuest Digital Dissertations database. (Publication No. AAT 8313578).

Fullan, M. G. (1992). *Successful school improvement: The implementation perspective and beyond*. Bristol, PA: Open University Press.

Fullan, M. G. (1993a). *Change forces: Probing the depths of educational reform*. New York: The Falmer Press.

Fullan, M. G. (1993b). Why teachers must become change agents. *Educational Leadership, 50*(6), 12-17.

Fuller, F. F. (1969). Concerns of teachers: A developmental conceptualization. *American Educational Research Journal, 6*(2), 207-226.

Gage, J. (2002). So what is an electronic whiteboard? Should you want one? *Micromath, 18*(2), 5-7.

George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Measuring implementation in schools: The stages of concern questionnaire* (2nd ed.). Austin, TX: Southwest Educational Development Laboratory.

George, A. A. & Rutherford, W. L. (1978). *Affective and behavioral change in individuals involved in innovation implementation.* ERIC Document Reproduction Service No. ED091439). Retrieved February 21, 2010, from EBSCOHost ERIC database.

Glover, D., & Miller, D. (2003). Players in the management of change: Introducing interactive whiteboards into schools. *Management in Education, 17*(1), 20-23.

Glover, D., Miller, D., Averis, D., & Door, V. (2005a). Leadership implications of using interactive whiteboards: Linking technology and pedagogy in the management of change. *Management in Education, 18*(5), 27-30.

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

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

Gordon, M. (2009). Toward a pragmatic discourse of constructivism: Reflections on lessons from practice. *Educational Studies, 45,* 39-58.

Hall, G. E. (1978). *Meeting the concerns of users: A way to implement competency testing*. Austin, TX: Research and Development Center for Teacher Education, the University of Texas. (ERIC Document Reproduction Service No. 189189). Retrieved February 21, 2010, from EBSCOHost ERIC database.

Hall, G. E., Dirksen, D. J., & George, A. A. (2006). *Measuring implementation in schools: Levels of Use* (2nd ed.). Austin, TX: Southwest Educational Development Laboratory.

Hall, G. E., & Hord, S. M. (1987). *Change in schools: Facilitating the process*. Albany: State University of New York.

Hall, G. E., & Loucks, S. F. (1977). A developmental model for determining whether the treatment is actually implemented. *American Educational Research Journal, 14*(3), 263-276.

Hall, G. E., Loucks, S. F., Rutherford, W. L., & Newlove, B. W. (1975). Levels of Use of the innovation: A framework for analyzing innovation adoption. *Journal of Teacher Education, 26*(1), 52-56.

Hall, G. E., Wallace, R. C., & Dossett, W. A. (1973). *A developmental conceptualization of the adoption process within educational institutions.* Austin, TX: Research and Development Center for Teacher Education, The University of Texas.

Hall, J., Chamblee, G., & Hughes, T. (2008). Teacher perceptions of interactive whiteboards: A comparison of users and future-users in high school and middle school mathematics. In K. McFerrin, et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2008* (pp. 4461-4467). Chesapeake, VA: AACE.

Hall, J., & Chamblee, G. (2009). Teacher perceptions of interactive whiteboards: A comparison of users and future-users in high school over a one year period. In I. Gibson, et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2009* (pp. 1857-1863). Chesapeake, VA: AACE.

Hall, J., & Chamblee, G. (2010). High school mathematics teachers and interactive whiteboards: A longitudinal study of 2 users and 2 future-users, year 3. In C. Crawford, et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2010* (pp. 3440-3447). Chesapeake, VA: AACE.

Harding, S. (1991). *Whose science? Whose knowledge? Thinking from women's lives.* Ithaca, NY: Cornell University Press.

Hegel, G. W. F. (1896). *Lectures on the history of philosophy.* (E. S. Haldane & F. H. Simson, Trans.). London: Paul, Trench, Trubner & Co.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies, 37*(2), 155-192.

Hennessy, S., Deaney, R., Ruthven, K., & Winterbottom, M. (2007). Pedagogical strategies for using the interactive whiteboard to foster learner participation in school science. *Learning, Media and Technology, 32*(3), 283-301.

House, E. R. (1994). Integrating the quantitative and qualitative. In C. S. Reichardt & S. F. Rallis (Eds.), *The qualitative-quantitative debate: New perspectives* (pp. 13-22). San Francisco: Jossey-Bass.

Hyerle, D. (1996). *Visual tools for constructing knowledge*. Alexandria, VA: Association for Supervision and Curriculum Development.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26.

Kant, I. (1902). *Critique of pure reason*. (J. M. D. Meiklejohn, Trans.). New York: American Home Library Company. (Original work published 1781).

Kaufman, B. A. (1979). Piaget, Marx, and the political ideology of schooling. In P. H. Taylor (Ed.), *New directions in curriculum studies* (pp. 71-96). Lewes, Sussex: The Falmer Press.

Kean, P. (1993, July/August). Reading, writing, and ripoffs: Fads in education. *Washington Monthly, 25,* 13-16.

Kennewell, S., & Beauchamp, G. (2007). The features of interactive whiteboards and their influence on learning. *Learning, Media and Technology, 32*(3), 227-241.

Key Curriculum Press. (n. d.). Welcome to The Geometer's Sketchpad resource center. Retrieved October 12th, 2009, from http://www.dynamicgeometry.com/

Kohn, A. (2000). *The schools our children deserve: Moving beyond traditional classrooms and "tougher standards."* New York: Houghton Mifflin.

Knight, P., Pennant, J., & Piggott, J. (2005). The power of the interactive whiteboard. *Micromath*, 21(2), 11-15.

Kuhn, T. S. (1996). *The structure of scientific revolutions* (3rd ed.). Chicago: University of Chicago Press.

Lewin, K. (1936). *Principles of topological psychology.* York, PA: McGraw-Hill Book Company.

Loucks-Horsley, S. (1996). Professional development for science education: A critical and immediate challenge. In R. W. Bybee (Ed.), *National standards & the science curriculum* (pp .83-90). Dubuque, IA: Kendall/Hunt Publishing Co.

Manzo, K. K. (2010). Whiteboards' impact on teaching seen as uneven [Electronic version]. *Education Week, 3*(2), 34. Retrieved January 30, 2010, from http://www.edweek.org/dd/articles/2010/01/08/02whiteboards.h03.html

Martin, A. (2008). Ideas in practice: Graphing calculators in beginning algebra. *Journal of Developmental Education, 31*(3), 20-37.

Marzano, R. J. (2009). Teaching with interactive whiteboards. *Educational Leadership, 67*(3), 80-82.

McKinnon, D. H., & Nolan, P. C. J. (1989). Using computers in education: A concerns-based approach to professional development for teachers. *Australian Journal of Educational Technology, 5*(2), 113-131.

Merrett, S. & Edwards, J. (2005). Enhancing mathematical thinking with an interactive whiteboard. *Micromath, 21*(3), 9-12.

Miller, D. & Glover, D. (2007). Into the unknown: The professional development induction experience of secondary mathematics teachers using interactive whiteboard technology. *Learning, Media and Technology, 32*(3), 319-331.

National Council for Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: NCTM.

Newhouse, C. P. (2001). Applying the Concerns-Based Adoption Model to research on computers in classrooms [Electronic version]. *Journal of Research on Computing in Education, 33*(5). Retrieved July 10, 2009, from http://www.iste.org/Content/NavigationMenu/Publications/JRTE/Issues/Volume_331/Number_5_Summer_2001/jrce-33-5-newhouse.pdf

Nicolle, P. S. & Lou, Y. (2008). Technology adoption into teaching and learning by mainstream university faculty: A mixed methodology study revealing the "How, when, why, and why not". *Journal of Educational Computing Research, 39*(3), 235-265.

Norman, D. A. (1993). *Things that make us smart: Defending human attributes in the age of the machine*. New York: Perseus Books.

Pass, S. (2004). *Parallel paths to constructivism: Jean Piaget and Lev Vygotsky.* Greenwich, CT: Information Age Publishing.

Piaget, J. (1964). *The child's conception of number*. (C. Gattegno & F. M. Hodgson, Trans.). London: Routledge & Kegan Paul LTD. (Original work published 1941).

Piaget, J., Inhelder, B., & Szeminska, A. (1981). *The child's conception of geometry.* (E. A. Lunzer, Trans.). New York: W. W. Norton & Company. (Original work published 1960).

Piaget, J. & Inhelder, B. (2000). *The psychology of the child.* (H. Weaver, Trans.). New York: Basic Books, Inc. (Original work published 1966).

Plato. (1989). The republic and other works. (B. Jowett, Trans.). New York: Anchor Books. (Original work published 360 B.C.E.)

Reardon, T. (2002). Interactive whiteboards in school: Effective uses. *Media & Methods,* 38(7), 12.

Richardson, A. (2002). Effective questioning in teaching mathematics using an interactive whiteboard. *Micromath, 18*(2), 8-12.

Rutherford, W. L., & Loucks, S. (1979, April). *Examination of the implementation of a junior high school's new approach to discipline by longitudinal analysis of change in teachers' Stages of Concern and Levels of Use.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, California, (ERIC No. ED207171)

Sandholtz, J.H., Ringstaff, C. & Dwyer, D.C. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: Teacher's College Press.

Schein, E. H. (1999). Kurt Lewin's change theory in the field and in the classroom: Notes toward a model of managed learning. *Reflections, 1*(1), 59-74.

Schifter, D. (2005). A constructivist perspective on teaching and learning mathematics. In C. T. Fosnot (Ed.), *Constructivism: Theory, Perspectives, and Practice (2nd Ed.)* (pp. 80-98). New York: Teachers College Press.

SEDL. (n. d.). Concerns-Based Adoption Model. Retrieved October 12th, 2009, from http://www.sedl.org/cbam/

Slough, S. W. (1999). Some concerns about the Concerns-Based Adoption Model (CBAM) and technology. In J. D. Price, J. Willis, D. A. Willis, M. Jost, & S. Boger-Mehall (Eds.), *Technology and teacher education annual, 1999* (pp. 1949-1953). Association for the Advancement of Computing in Education, Charlottesville, VA.

Solvie, P. A. (2004). The digital whiteboard: A tool in early literacy instruction. *Reading Teacher, 57*(5), 484-487.

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: SAGE Publications, Inc.

Stiegler, B. (1998). *Technics and time, 1: The fault of Epimetheus.* (R. Beardsworth & G. Collins, Trans.). Stanford, CA: Stanford University Press. (Original work published 1994).

Tanner, H., & Jones, S. (2007). How interactive is your whiteboard?. *Mathematics Teaching Incorporating Micromath, 200*, 37-41.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches.* Thousand Oaks, CA: SAGE Publications, Inc.

von Glasersfeld, E. (1998). Why constructivism must be radical. In M. Larochelle, N. Bednarz, & J. Garrison (Eds.), *Constructivism and education* (pp. 23-28). New York: Cambridge University Press.

von Glasersfeld, E. (2005). Introduction: Aspects of constructivism. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (2nd ed.) (pp. 3-7). New York: Teachers College Press.

Vygotsky, L. S. (1997). *Educational psychology*. (R. Silverman, Trans.). Boca Raton, FL: St. Lucie Press. (Original work published 1926).

Weaver, J. A. (2001). Introduction: (Post) modern science (education): Propositions and alternative paths. In J. A. Weaver, M. Morris, & P. Appelbaum (Eds.), *(Post) modern science (education): Propositions and alternative paths* (pp. 1-22). New York: Peter Lang.

Windschitl, M. (1999). The challenges of sustaining a constructivist classroom culture. *Phi Delta Kappan, 80*(10), 751-755.

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

APPENDIX A

CBAM STAGES OF CONCERN QUESTIONNAIRE

Name: _____

The purpose of this questionnaire is to determine what people who are using or thinking about using Interactive Whiteboards are concerned about at various times during the adoption process. The items were developed from typical responses of school and college teachers who ranged from no knowledge at all about various programs to many years' experience using them. Therefore, **many of the items on this questionnaire may appear to be of little relevance or irrelevant to you at this time.**

For the completely irrelevant items, please circle "0" on the scale. Other items will represent those concerns you do have, in varying degrees of intensity, and should be marked higher on the scale.

For example:

This statement is very true of me at this time.	0 1 2 3 4 5 6 (7)
This statement is somewhat true of me now.	0 1 2 3 (4) 5 6 7
This statement is not at all true of me at this time.	0 (1) 2 3 4 5 6 7
This statement seems irrelevant to me.	(0) 1 2 3 4 5 6 7

Please respond to the items in terms of **your present concerns,** or how you feel about your involvement with **Interactive Whiteboards**. We do not hold to any one definition of IWBs so please think of it in terms of your own perception of what it involves. Phrases such as "this approach" and "the new system" all refer to IWBs. Remember to respond to each item in terms of your present concerns about your involvement or potential involvement with IWBs.

Thank you for taking time to complete this task.

0	1 2	3 4 5	6 7
Irrelevant	Not true of me now	Somewhat true of me now	Very true of me now

Circle One Number For Each Item

1. I am concerned about students' attitudes toward the innovation.	0 1 2 3 4 5 6 7
2. I now know of some other approaches that might work better.	0 1 2 3 4 5 6 7
3. I am more concerned about another innovation.	0 1 2 3 4 5 6 7
4. I am concerned about not having enough time to organize myself each day.	0 1 2 3 4 5 6 7
5. I would like to help other faculty in their use of the innovation.	0 1 2 3 4 5 6 7
6. I have a very limited knowledge of the innovation.	0 1 2 3 4 5 6 7
7. I would like to know the effect of reorganization on my professional status.	0 1 2 3 4 5 6 7
8. I am concerned about conflict between my interests and my responsibilities.	0 1 2 3 4 5 6 7
9. I am concerned about revising my use of the innovation.	0 1 2 3 4 5 6 7
10. I would like to develop working relationships with both our faculty and outside faculty using this innovation.	0 1 2 3 4 5 6 7
11. I am concerned about how the innovation affects students.	0 1 2 3 4 5 6 7
12. I am not concerned about the innovation at this time.	0 1 2 3 4 5 6 7
13. I would like to know who will make the decisions in the new system.	0 1 2 3 4 5 6 7
14. I would like to discuss the possibility of using the innovation.	0 1 2 3 4 5 6 7
15. I would like to know what resources are available if we decide to adopt the innovation	0 1 2 3 4 5 6 7
16. I am concerned about my inability to manage all that the innovation requires.	0 1 2 3 4 5 6 7
17. I would like to know how my teaching or administration is supposed to change.	0 1 2 3 4 5 6 7

0	1 2	3 4 5	6 7
Irrelevant	Not true of me now	Somewhat true of me now	Very true of me now

Circle One Number For Each Item

18. I would like to familiarize other departments or persons with the progress of this new approach. 0 1 2 3 4 5 6 7

19. I am concerned about evaluating my impact on students. 0 1 2 3 4 5 6 7

20. I would like to revise the innovation's approach. 0 1 2 3 4 5 6 7

21. I am preoccupied with things other than the innovation. 0 1 2 3 4 5 6 7

22. I would like to modify our use of the innovation based on the experiences of our students. 0 1 2 3 4 5 6 7

23. I spend little time thinking about the innovation. 0 1 2 3 4 5 6 7

24. I would like to excite my students about their part in this approach. 0 1 2 3 4 5 6 7

25. I am concerned about time spent working with nonacademic problems related to the innovation. 0 1 2 3 4 5 6 7

26. I would like to know what the use of the innovation will require in the immediate future. 0 1 2 3 4 5 6 7

27. I would like to coordinate my efforts with others to maximize the innovation's effects. 0 1 2 3 4 5 6 7

28. I would like to have more information on time and energy commitments required by the innovation. 0 1 2 3 4 5 6 7

29. I would like to know what other faculty are doing in this area. 0 1 2 3 4 5 6 7

30. Currently, other priorities prevent me from focusing my attention on the innovation. 0 1 2 3 4 5 6 7

31. I would like to determine how to supplement, enhance, or replace IWBs. 0 1 2 3 4 5 6 7

32. I would like to use feedback from students to change the program. 0 1 2 3 4 5 6 7

33. I would like to know how my role will change when I am using IWBs. 0 1 2 3 4 5 6 7

0	1	2	3	4	5	6	7
Irrelevant	Not true of me now		Somewhat true of me now			Very true of me now	

Circle One Number For Each Item

34. Coordination of tasks and people is taking too much of my time. 0 1 2 3 4 5 6 7

35. I would like to know how the innovation is better than what we have now. 0 1 2 3 4 5 6 7

Please complete the following:

1. How long have you been involved with the innovation, not counting this year?

Never ___ 1 year ___ 2 years ___ 3 years ___ 4 years ___ 5 or more ____

2. In your use of the innovation, do you consider yourself to be a:

non-user ___ novice ___ intermediate ___ old hand ___ past user ____

3. Have you received formal training regarding the innovation (workshops, courses)?

Yes ____ No ____

4. Are you currently in the first or second year of use of some major innovation or program other than this one?

Yes ____ No ____

If yes, please describe briefly:

Thank you for your help!

Adapted from George, Hall, & Stiegelbauer (2006)

APPENDIX B

LEVEL OF USE INTERVIEW PROTOCOL

Questions
1. Are you using the innovation?
If yes, then proceed to Question 2 (Note: All participants said yes to Q1)
2. What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?
3. Are you currently looking for any information about the innovation? What kind? For what purpose?
4. Do you ever talk with others about the innovation? What do you tell them?
5. What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?
6. Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?
7. As you look ahead to later this year, what plans do you have in relation to your use of the innovation?
8. Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?
9. Are you considering making or planning to make major modifications or to replace the innovation at this time?
If yes to Q8, then ask the following:
10. How do you work together? How frequently?
11. What are the strengths and the weaknesses of this collaboration for you?
12. Are you looking for any particular kind of information in relation to this collaboration?
13. When you talk to others about your collaboration, what do you share with them?
14. Have you done any formal or informal evaluation of how your collaboration is working?
15. What plans do you have for this collaborative effort in the future?
16. Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Adapted from Hall, Dirksen, and George (2006, pp. 53-54)

APPENDIX C

LoU PROBING QUESTIONS

1. How do you typically use your IWB?

2. What pedagogical strategies do you use with your IWB?

3. What are your personal views about IWBs in general?

4. What is your personal view about your own IWB usage specifically?

5. Do you have any concerns regarding IWB use in the classroom?

6. Do you have any other comments about IWBs?

APPENDIX D

IWB TEACHER FOLLOW-UP QUESTIONS

1. Were the video-recorded lessons representative of how you typically use your IWB?

2. How were they similar to other lessons involving your IWB?

3. How were they different to other lessons involving your IWB?

4. What pedagogical strategy/strategies did you use in the lessons?

5. Did you have any concerns regarding IWB use before, during, and/or after the lessons?

6. Do you have any other comments about IWBs?

APPENDIX E

SOCQ STATEMENT LINE ITEMS BY STAGE

Stage 0 - Awareness

Item	Statement
3	I am more concerned about another innovation.
12	I am not concerned about this innovation at this time.
21	I am preoccupied with things other than this innovation.
23	I spend little time thinking about this innovation.
30	Currently, other priorities prevent me from focusing my attention on this innovation.

Stage 1 - Informational

Item	Statement
6	I have a very limited knowledge of the innovation.
14	I would like to discuss the possibility of using the innovation.
15	I would like to know what resources are available if we decide to adopt this innovation.
26	I would like to know what the use of the innovation will require in the immediate future.
35	I would like to know how this innovation is better than what we have now.

Stage 2 - Personal

Item	Statement
7	I would like to know the effect of the innovation on my professional status.
13	I would like to know who will make the decisions in the new system.
17	I would like to know how my teaching or administration is supposed to change.
28	I would like to have more information on time and energy commitments required by this innovation.
33	I would like to know how my role will change when I am using the innovation.

Stage 3 - Management

Item	Statement
4	I am concerned about not having enough time to organize myself each day.
8	I am concerned about conflict between my interests and my responsibilities.

16	I am concerned about my inability to manage all the innovation requires.
25	I am concerned about time spent working with nonacademic problems related to this innovation.
34	Coordination of tasks and people is taking too much of my time.

Stage 4 - Consequence

Item	Statement
1	I am concerned about students' attitudes toward this innovation.
11	I am concerned about how the innovation affects students.
19	I am concerned about evaluating my impact on students.
24	I would like to excite my students about their part in this approach.
32	I would like to use feedback from students to change the program.

Stage 5 - Collaboration

Item	Statement
5	I would like to help other faculty in their use of the innovation.
10	I would like to develop working relationships with both our faculty and outside faculty using this innovation.
18	I would like to familiarize other departments or people with the progress of this new approach.
27	I would like to coordinate my effort with others to maximize the innovation's effects.
29	I would like to know what other faculty are doing in this area.

Stage 6 - Refocusing

Item	Statement
2	I now know of some other approaches that might work better.
9	I am concerned about revising my use of the innovation.
20	I would like to revise the innovation's instructional approach.
22	I would like to modify our use of the innovation based on the experiences of our students.
31	I would like to determine how to supplement, enhance, or replace the innovation.

Adapted from George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Measuring implementation in schools: The stages of concern questionnaire* (2nd ed.). Austin, TX: Southwest Educational Development Laboratory.

APPENDIX F

STAGES OF CONCERN QUESTIONNAIRE DATA BY STAGE

Stage 0 – Awareness

Participant	Item 3	Item 12	Item 21	Item 23	Item 30	Mean	Percentile
A	2	6	1	3	1	2.6	75
B	1	3	1	1	3	1.8	48
C	0	1	3	7	6	3.4	94
D	2	2	6	6	6	4.4	99
E	1	7	1	1	1	2.2	61
F	1	1	1	6	0	1.8	48

Stage 1 – Informational

Participant	Item 6	Item 14	Item 15	Item 26	Item 35	Mean	Percentile
A	3	0	4	4	2	2.6	51
B	5	1	3	5	1	3	57
C	4	5	7	4	4	4.8	88
D	5	1	3	3	6	3.6	66
E	2	1	1	1	1	1.2	30
F	1	0	0	0	4	1	27

Stage 2 – Personal

Participant	Item 7	Item 13	Item 17	Item 28	Item 33	Mean	Percentile
A	0	0	3	2	2	1.4	31
B	0	1	4	1	1	1.4	31
C	1	3	3	4	4	3	75
D	0	1	3	3	3	2	41
E	0	1	1	1	1	0.8	21
F	4	1	4	0	0	1.8	39

Stage 3 – Management

Participant	Item 4	Item 8	Item 16	Item 25	Item 34	Mean	Percentile
A	2	1	2	1	1	1.4	23
B	1	1	1	1	1	1	15
C	1	1	1	5	2	2	34
D	6	2	4	3	6	4.2	80
E	1	1	1	1	1	1	15
F	4	1	0	2	4	2.2	39

Stage 4 – Consequence

Participant	Item 1	Item 11	Item 19	Item 24	Item 32	Mean	Percentile
A	1	2	2	6	4	3	16
B	1	4	4	6	3	3.6	24
C	6	6	6	7	6	6.2	82
D	1	2	1	6	3	2.6	11
E	1	1	1	7	4	2.8	13
F	1	7	4	5	0	3.4	21

Stage 5 – Collaboration

Participant	Item 5	Item 10	Item 18	Item 27	Item 29	Mean	Percentile
A	7	6	7	6	5	6.2	91
B	4	5	5	7	5	5.2	72
C	3	3	3	6	5	4	48
D	1	2	1	4	3	2.2	16
E	7	7	4	5	5	5.6	80
F	7	7	3	6	5	5.6	80

Stage 6 – Refocusing

Participant	Item 2	Item 9	Item 20	Item 22	Item 31	Mean	Percentile
A	4	3	1	2	4	2.8	38
B	1	1	1	5	7	3	42
C	6	1	6	5	6	4.8	81
D	2	2	1	3	3	2.2	26
E	1	1	1	6	3	2.4	30
F	3	6	0	6	3	3.6	57

APPENDIX G

MODEL LESSONS FOR EACH LEVEL OF USE

Level III

The user is a very inexperienced at using an IWB. The user's lesson incorporates the IWB sparingly, if at all. If it is used, it is used in a superficial manner only. That is, the user treats the IWB almost like an LCD projector with no regard for its touch sensitivity capabilities. Students do not physically use the IWB themselves.

Level IV A

The user has become very comfortable using an IWB, but does not stretch its capabilities beyond its basic functions. Usage is standardized and does not change much according to the material being taught. Older technologies are used in conjunction with the IWB, despite the ability of IWBs to duplicate and replace the older technologies. Students interact with the IWB sparingly, it at all.

Level IV B

The user experiments with new capabilities and techniques in order to improve student learning. Increasing student interaction with the IWB becomes a goal. The IWB has become an integral part of lessons, used almost exclusively throughout class. Users at this level wonder how they taught without the IWB before, and claim they would have trouble teaching without one.

Level V

The user has started collaborating with other IWB users in order to improve student learning and performance. Lesson material is created and shared to alleviate the time required to plan lessons, enabling more complex lessons that utilize more IWB capabilities. Student interaction with the IWB or its files is common.

Level VI

The user is an expert at incorporating an IWB into a classroom lesson. The IWB is used to differentiate lessons for different learning styles. Other new technologies are used in conjunction with, or even as an alternative to, the IWB to improve the learning experience for students. The user is exceedingly familiar with both the capabilities and limitations of the IWB and adapts lessons accordingly.

Adapted from the guidelines of Hall, Dirksen, and George (2006)

APPENDIX H
LEVEL OF USE PROTOCOL RESPONSES BY PARTICIPANT

Participant A

Question 1: Are you using the innovation?

Participant A answered this affirmatively by saying "yes, we are." She then said, "we use it pretty much every day." Her use of the personal pronoun "we" instead of "I" is reflective of the team-teaching arrangement of her classes as described previously in the Participants section of this chapter.

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

Participant A said that IWB's board was "larger, so more students are able to see it." She also noted that her IWB was installed on a bulletin board instead of an existing whiteboard, so she was able to take full advantage of both as what she called "two learning stations." She also described the ability to save her IWB notes and post them on-line for her students as a strength.

Regarding weaknesses, she mentioned that "it takes us more time to plan to use it." She explained that in the past, she was able to "just show up to class" and write on the whiteboard. Since getting her IWB earlier in the school year, she said that "now, we plan ahead so we can create a decent presentation." She also mentioned that "Activators," which can be used by students to input multiple choice answers to be output on the IWB screen, can be fun for students to use, but that they take "a lot of planning" to implement. Participant A summarized by saying that increased planning time "was the biggest weakness" of teaching with IWBs.

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Participant A said that she and her team-teacher were looking for more information. She mentioned that a Promethean representative, who already taught her how to use IWB-related software such as Activstudio and ActivInspire earlier in the fall semester, would be returning during the spring semester to teach her more about the IWB's capabilities. She was mainly trying to learn new tips on how to better use her IWB's functionalities.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant A said that yes, she spoke with her team-teacher often about IWB use. She mentioned that the two of them were the only teachers in the school with Promethean IWBs. They planned their lessons together and shared IWB materials.

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Participant A said that "the feedback from students is they seem to like it...seem to like using it." She said that the "outgoing kids" were "more eager" to volunteer to write on the IWB or use the wireless tablet input device that was used in conjunction with her IWB. She also mentioned that following a lesson of new material or during a review of

old material, she allowed her students to come up to the IWB and toggle through the notes to see problems that she and her classes had done previously on the board.

Regarding reactions to IWBs, she said, “I think teachers are more intrigued by it than the kids...it's just kind of old hat.” She mentioned that the kids were “used to technology,” so having IWB technology in her classroom was not overwhelming for her students. She said that IWB technology was “new to [her] high school, but it's not new to the kids because they have a lot of innovation in middle school and elementary school.” This comment reflected her opinion that the middle and elementary schools in her school's cluster received more funding for technology than the high school, particularly from parent groups.

Regarding the effects of IWB use in her classroom, she said that “the effects are really helpful” primarily because she can save her work and post the material on-line. That way, her students have “no excuse if they're absent or if they didn't understand something or miss something...they have access to everything.” She summarized by calling this function “a huge advantage.” She did not mention any formal or informal evaluation of her IWB use.

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

Participant A responded with a “no” to the first question. She mentioned her occasional usage of the Activator buttons and the tablet input device, but she mostly used her IWB to display notes and mathematics problems in class. At the time of the interview, Participant A had only been using her IWB for less than one semester, so she

had been using her IWB in this fashion from the beginning. She was not considering making any changes.

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

Participant A said that she and her team-teacher "definitely want to keep learning more about it and keep incorporating more and more into the classroom and get the kids more involved in using it." She wanted to use the tablet input device more, but she said that her students take so long getting acclimated to using it that it "kind of kills the energy." Her goal was to get her students involved more often so that the acclimation process was not so problematic for them.

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

Participant A mentioned her collaborative efforts with her team-teacher again, saying that "we spend a lot of time talking about them." She also mentioned working with Participant F, who teaches next door to her and is the most experienced IWB user in the school with approximately three and a half years of experience at the time of this study. She described the process they use to share files between his SMART Board and her Promethean board, which involves converting IWB-proprietary file formats into Microsoft's PowerPoint format which can then be accessed by both brands of IWBs. She also shared her IWB files with a teacher who did not have an IWB installed but did have an LCD projector in her room. This teacher was still able to utilize IWB files in her

classroom, but could not take advantage of the touch-sensitivity and other unique features of IWBs.

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

Participant A said "no, we want to keep them." She also said that she "loved having them on the bulletin board" as opposed to being installed on top of the whiteboards in the room. She suggested that any teacher that gets an IWB should install it on something other than a whiteboard since it allowed the full use of both types of boards.

Question 10: How do you work together? How frequently?

Participant A met every Wednesday with either Integrated Algebra 1 teachers or Integrated Geometry teachers. These meetings were more focused on content material being taught in those classes, not on IWB use. For IWB issues, she collaborated on a daily basis with her team-teacher. She called their shared classroom "a huge advantage" that made collaborating a lot easier. She noted that every item that was projected on her IWB had been produced or obtained via this collaboration.

Question 11: What are the strengths and the weaknesses of this collaboration for you?

Participant A said that a strength of her shared classroom was that she had "a lot more options." She did not elaborate on this remark any further in this particular interview, but she had mentioned in previous discussions that her team-teaching in a double classroom allowed her to differentiate instruction more by breaking students up

into groups based on assessment performance. She could also use her neighbor's classroom, belonging to Participant F, when she differentiated among students from three classes.

As a possible weakness, she mentioned that the shared classroom approach required students to be more "open-minded" since it was not conducted like a traditional classroom. She thought it appealed to those students who were looking for something "fresh and new." She described it as "a new take on math." Overall, she thought the "strengths definitely outweigh the weaknesses" of collaboration.

Question 12: Are you looking for any particular kind of information in relation to this collaboration?

Participant A said "no" to this question, but said she remained open-minded to learning new things. She said she felt "pretty knowledgeable" about her IWB, especially since she could use it everyday. She "couldn't imagine" having to use an IWB in another teacher's room, because "unless you're working with it day-in and day-out, you're not going to get better at it."

Question 13: When you talk to others about your collaboration, what do you share with them?

Participant A has told others about her and her team-teacher's collaboration that "we love it." She has told them that "we don't want to go back" to a more traditional classroom arrangement. It should be noted that these comments were about her double-sized open classroom and her team-teaching arrangement in general as well as her IWB collaborations.

Question 14: Have you done any formal or informal evaluation of how your collaboration is working?

Participant A said she had done a formal evaluation via a student survey, finding "the mean, the standard deviation, everything." She conducted the survey around the mid-point of the semester and wanted to know how her students felt about the team-teaching, the open classroom arrangement, and the IWBs. She was hoping that the students would all say "we love it," but her results were mixed.

She was happy to note that on one question in particular, which asked if students felt comfortable around at least one of the three collaborating teachers, she received very positive feedback. She felt this was important because she thinks students learn mathematics better when they ask questions, so she wanted her students to feel comfortable approaching at least one of the three team teachers for help. Her collaborative efforts should therefore allow students to learn mathematics better.

Question 15: What plans do you have for this collaborative effort in the future?

Participant A said that she planned to continue her collaboration into the spring semester so that she could have a full year of data from her experiment. She said if it were her choice, she would repeat the effort next school year. She said it had been a "positive experience" overall.

Question 16: Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Participant A said "I'd definitely like to keep learning more about it." She did not necessarily think that IWBs will improve student performance, but they were useful for

keeping students engaged in class and for exposing them to technology. She thinks IWBs give students "more opportunities" to perform better "if they are willing to take advantage of them". For example, she mentioned that she projects an on-line textbook on her IWB screen that allows all her students to see. She also said that the audio-visual features of her IWB, like the big screen and nice speakers, makes her classroom feel "like the movies" when she plays music for her students or shows movie clips, all of which brings a positive energy that is not usually found in mathematics classrooms.

Participant B

Question 1: Are you using the innovation?

Participant B responded that yes, he does use the innovation. He explained that he "started using it this [school] year" when he moved into his new classroom inside the main school building. He had previously taught in a portable trailer classroom located on the periphery of the main building. It did not have an IWB installed. Now that he had one in his classroom, he said he has "pretty much been using it the entire year."

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

Participant B said that one of the main strengths is of the IWB was its ability to increase student focus on lessons. This was partly due to its technological nature in general, but also because the screen was "bigger for the kids to see." As a teacher, he liked writing on the IWB and appreciated its ability to access computer files or "pull up graphs". He mentioned how much easier it was to pull up worksheets on the IWB in

order to do problems with his class. He noted that "a lot of times, just having to erase so much during class can take up time," so the ability to quickly erase work and pull up new problems was a strength in his opinion.

For weaknesses, Participant B did not address any shortfalls about the IWB technology itself, but instead focused on his own issues as an end user. He said that "there's a lot of things I don't know how to do with a SMART Board." He claimed that "honestly, the kids have taught me a lot because they've learned about it coming up through middle school and everything, so I try not to act close-minded. They teach me things and I can learn from them, as well."

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Regarding his IWB, Participant B said that he'd "just like to be able to do more on it." He knew there were "different features in different subject areas" that he could access, and he wanted to be able to use them in his integrated mathematics classes. He said that he had not tried to get any training on his IWB due to time limitations, but that he would "really like to try" to attend a clinic or workshop in the summer when he had more time to devote to learning about it.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant B said that he did talk to others, including those who were "less experienced like I am and others who are more experienced." He said he told them about the "advantages and disadvantages of [the IWB]." One problem he discussed concerned

the “colored markers” that serve as input devices on his IWB. Depending on which marker is active, the color of the writing on the screen can be changed. He said they were “hard to keep up with sometimes,” and that he had discussed “even something as simple as being able to change colors on it all the time to represent different graphs and things like that.”

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Participant B said that “ultimately, I still think that obviously the teacher is the biggest impact on the students...somebody who all students can learn from can go up there and teach without a SMART Board.” He noted, however, that IWBs “can enhance [and] make things quicker.... I can get more things done.” For students, he thought “that light bulb, a lot of times, can click easier, too.” He said he was not doing anything to evaluate himself, but “maybe I should.”

He said “students don't give too much feedback about it. They seem pretty positive about what we do.” He noted that his students “think it's cool or something” and wanted to show him how to do new things on the IWB. He said they did so not merely to be helpful, but because “they want to get up there and play on it themselves.”

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

Participant B said, “I haven't made too many changes.” Among the changes he had made, he mentioned that “now I try to save notes so kids who are absent can see things.” Saving documents enabled students to review previous lessons when they returned to class.

He also mentioned his tactic of “pulling documents up” on to the IWB screen in order to do problems with his students, something he now did often but “didn't do hardly at all at the beginning of the school year.” Part of the reason for this increase was due to his learning more about how to use the IWB software. For example, he said he has “learned a lot” about writing on the IWB screen, and mentioned how he used to just write with the IWB's stylus to annotate documents on the screen. When he then tried to scroll the document to a different spot, the IWB software would automatically clear off his annotations against his wishes. He learned that he could make his annotations permanent by using the “copy-and-paste” process onto the document itself.

Participant B summarized this question by saying there were “a lot of little things...that I have learned to do better.” For example, he explained that his LCD projector was positioned approximately 10 feet from the IWB. It sat on a desk in the middle of the classroom, so he used to have problems with blocking the image from being seen on the screen. He had since learned how to write on the screen and manipulate the IWB “by moving to the side.” He described this as a “little thing,” but learning many such little things had been a big part of his IWB experience.

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

Participant B said that he "wish[ed] he had more plans," but did not have "any plans to do anything different." He did plan, though, to "keep using" his IWB in the future. Regarding his IWB, Participant B said, "I really do like it. I like it more than I even thought I would, honestly." He explained that he likes using his IWB for "selfish reasons, because it makes life easier for me, but I also think just any technology you can use, a lot of times even if you're writing the same thing on there you would write on the [traditional] board that, for some reason, it intrigues the kids and captures their attention."

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

Participant B said, "No, I haven't really worked with any others." He explained that he has had "just a few casual conversations" about IWB use with other teachers. He then said that, he "wouldn't mind" working with others about IWB issues. He said, "I'd actually like to do that, but I have not yet."

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

Participant B responded that he would not be making any "major modifications" to his current IWB usage. He reaffirmed his affinity for his IWB and said he plans to "keep using it". He said "it would be tough to go without one when you get used to it."

Participant B planned to keep using his IWB and that he could "hopefully learn more about it". While he repeated his desire to attend "a clinic" to learn more about IWB technology, he thought he could just learn more about it by "play[ing] with the features" himself. He thought he "could figure most of it out" himself, but that it would require a time commitment in the future. He said it was "just something that [he's] got to take the time to do".

Note: Since Participant B responded negatively to Question 8, he was not asked Questions 10 through 16 involving IWB collaboration.

Participant C

Question 1: Are you using the innovation?

Participant C responded with a straightforward "yes" to this question.

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

Regarding the strengths of IWBs, Participant C noted the ability to display software on a large screen. For example, she was "able to project things on my computer such as [statistical software] Fathom, and [is] able to show students histograms and analyze data. It makes it very powerful because they can visualize concepts that you used to not be able to visualize."

As a statistics teacher, Participant C mentioned that using an IWB "saves time as far as collecting data, as well, because students can type in their data and we can analyze it in seconds, where as in the past prior to having the whiteboard, we'd have to take time

to type it into the calculator and then take time to analyze it. It would be much more time-consuming". With the abilities of her IWB, she was now "able to finish a concept in a lesson in 55 minutes, whereas before it would probably take two or three days". The end result was the potential to cover more topics or cover existing topics in more depth.

As far as IWB weaknesses were concerned, Participant C said she could not name any, but she admitted to not using it every day. She did not use her IWB when her students did group work, for example. She said, "when I do use it, it is very powerful, very motivating for students." She explained that "students like to see it," which she considered "a bonus."

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Participant C said she was "pretty satisfied" with her IWB for what she "needs to use it for right now," so she was not looking for any information about IWBs at the time of the interview. If she did "find out more things, then [she] might be more open to possibilities of using it in other ways." Ultimately, she said she "would be interested" in learning more about the IWB if it could help her teach better.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant C said that she spoke to people about IWBs during the previous school year, which was the first year she had the IWB in her classroom. For example, she spoke to the "math department head about how powerful it was for statistics, because...it really makes things more visual for the students." She also thought it could be "very powerful

for geometry because programs such as GSP [Geometer's Sketchpad] can be projected and manipulated as well as statistics." She informed the department head that "for those types of classes, even if we didn't have the SMART Board, [using] the projector alone so we could see what was on the computer would be great." Still, given the overlap in capabilities between IWBs and LCD projectors alone, she said having a "SMART Board is nice because you can actually use it like a mouse and you can actually use your hands, which [is] even more fun for students to watch".

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Participant C answered the evaluation part first. She said she had not done any formal assessments because she did "not really have a control group." She said she was using the IWB software in all of her classes, so it was "very difficult to compare" without a class that does not get her IWB treatment. She noted that since she shared her classroom with a part-time teacher, she had to teach in a neighboring classroom that did not have an IWB installed. To work around this limitation, she simply used an LCD projector and the IWB software on her teacher laptop in order to replicate the experience for that particular classroom.

Regarding student motivation and IWB, she believed that "they really like it." As an example, Participant C mentioned that when students came to see her in her regular classroom for tutoring, the students from the class that did not have an IWB were

impressed with her IWB. These students told her that "they wished they had the SMART Board next door because they thought they would be more motivated to see it."

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

Participant C said she could not think of any changes that she had made in the current school year. She added that she had made no recent changes, at least "not so far". She did not mention any changes that she was considering for the future.

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

Participant C said she "should probably have more student interaction with it." She said she has "a good deal" of student participation in her AP Statistics courses already. For example, her AP Statistics "students come up to the board, they type things in, they use it regularly."

In contrast, her Integrated Geometry students "just come up and play with [the IWB] before class begins." In these classes, she said that she has not done "much data collection or [had] them coming up to use it" compared to her AP Statistics classes. She said her Integrated Geometry classes "would be a good place where I could try to get them to use it more because they do like doing that."

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

Participant C said she had not made any changes this year, but had "referred to a few people" during the previous year. She had spoken to Participant F and other "people that had SMART Boards for a year." One of the teachers she mentioned had received an IWB at the same time as Participant F, but had since left public education for a job in industry. She had asked them questions about her IWB, but had not asked any questions during the current school year.

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

Participant C said she was not considering replacing her IWB. She did not mention that she was making any major modifications to her IWB use. She also did not mention any plans for such modifications.

Question 10: How do you work together? How frequently?

Participant C said that she works with Participant D "on a regular basis" because they share a room. One of them will usually set the IWB up in the morning before school starts, and they coordinate tasks and Fathom programs for use in AP Statistics. Both of them teach AP Statistics, so Participant C described it as a "team teach" process. They do not teach during the same period together, but they so do share their lessons and what they plan to do with the IWB. She said they "work together and coordinate [their] efforts that way."

Question 11: What are the strengths and the weaknesses of this collaboration for you?

Participant C said she does not see "any weaknesses" in their collaboration. She said everything was "strong" and "very helpful." For example, she mentioned that Participant D "will think of things creative that [Participant C] might not have thought of or vice versa." She said they could "put more ideas up there [and] do more things together with two of [them] working rather than just one."

Question 12: Are you looking for any particular kind of information in relation to this collaboration?

Participant C responded, "No, not at this time."

Question 13: When you talk to others about your collaboration, what do you share with them?

Participant C said she "hadn't really talked lately" to anyone about her collaborative efforts. She said she spoke more about it to people last year. When speaking with her collaborator, she said that she and Participant D often agree that "it's a really good thing" that they are "stuck in a room together." Otherwise, they "would not collaborate as much as [they] do because there's not enough time in the day and you have students coming in and interrupting constantly." She also described how she shares a planning period with Participant D. She called this time "very valuable" since they do not have any other time to collaborate due to scheduling conflicts. It allows them to have "daily collaboration."

Question 14: Have you done any formal or informal evaluation of how your collaboration is working?

Participant C responded “no and no” to this question.

Question 15: What plans do you have for this collaborative effort in the future?

Participant C said “hopefully we'll still have time off together like we do so we can collaborate. That's very helpful to both of us.” She thought that their schedules would continue to give them a common planning period in the future.

Question 16: Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Regarding her IWB skills, Participant C described herself as “not a novice” but “not advanced, either.” She described it by saying it was “like with anything technical,” she learned what was required in order to use it, and then learned little more beyond that. She said this was because she did not “have enough time to play, not as much time as [she would] like.”

Participant D

Question 1: Are you using the innovation?

Participant D simply said “yes” to this question.

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

Participant D said that strengths of the IWB included the fact that her “kids can see exactly what [she's] doing” on the computer. She also mentioned the ability to save

what she does in class so she can print copies for absent students. She described it as "easily accessible" for her to "put things on-line for the kids" who are absent. She called this "a definite strength."

For Participant D, weaknesses included "recalibrating quite often because kids hit the machine, hit the projector." Her LCD projector sat on a desk in the center of the room, so it was in the path of students as they walked to their seats. If the desk or projector got bumped, the IWB touch-screen had to be recalibrated. If not, the touch inputs were not aligned with the computer's output and it became disorienting.

Another weakness she mentioned was that handwriting on the IWB "not as neat and clear" as handwriting done on a traditional overhead projector. While writing with an IWB stylus involves the same mechanics as any writing in general, the output is often not as precise. The process of writing on an IWB's touch-screen, which involves the IWB transmitting a signal to the computer to be processed and then sent to the LCD for projection back to the touch-screen, typically results in output that looks less precise than traditional handwriting.

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Participant D responded with a "No." She said she was "not really looking for information." She said she was just learning how to use her IWB as she went along in order to "better" herself and "to see what would help the kids more." She described it as "a slow process" for her.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant D has talked with others about her IWB in the past. She generally told them what she liked about her IWB. She said that since she was a part-time teacher, she did not have much time to talk with people about it.

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Participant D said she was "not really doing any evaluating, either formally or informally." She said she used her IWB and tried to improve herself and "to know a little more about it every time" she used it.

Regarding feedback from students, Participant D said that her "kids love it because they think it's fun with the different colors." She said they were not "really concerned about the learning process, more about the fun of writing on the [interactive] whiteboard and how it goes away and how they can...have fun with it." She said she was not sure if her IWB had "really enhanced" her classroom.

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

Participant D said that the main change she has made to her IWB usage was to produce word-processed notes before teaching a lesson. She then projected the document on the screen during class, relieving her from handwriting notes entirely with a stylus.

Displaying a typed document made her notes more “clear” and “very big” so students could see it. She said this change helped her alleviate the “sloppiness” of notes handwritten with the stylus. She still annotated her notes in class and worked out mathematics problems with a stylus, but she believed that the main notes for her lessons were easier to read now.

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

Participant D said she really liked to use her IWB in class when she used the statistical software program entitled Fathom. She said, “When I collect data in class, I really like to use the SMART Board because I can show them diagrams and graphs, and [students] can actually see things moving as we collect the data. They enjoy that.” She intended to keep using Fathom. In the future, she planned to use her IWB in “the same manner” as she had in the past, primarily for displaying Fathom and word-processed notes. She said that she did not have “any additional plans” beyond that.

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

Regarding IWBs, Participant D had only ever worked with Participant C. She said she had “never been trained to use [the IWB].” She elaborated: “I was kind of given the SMART Board one day, and the next day I used it and taught myself what I was doing...[Participant C] and I.”

Participant D said that she had had "not been giving any formal training," although she had seen other people use an IWB. She said she knew there were "a lot of possibilities out there" regarding things she did not know about her IWB. She did not indicate if she would seek any training to explore these possibilities.

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

Participant D said that she was not planning to make any modifications to her IWB usage. She said she would "enjoy taking a class to learn how to use [her IWB] and get more time hands-on" with it. She lamented that she could not learn very much about her IWB on a daily basis because of her time restraints as a part-time teacher.

Question 10: How do you work together? How frequently?

Participant D said she collaborated with Participant C "all the time." She said they talked about how they were going to use the IWB in their lessons. They also helped each other with lesson plans and IWB resources in order to be consistent across classes and reduce planning time.

Question 11: What are the strengths and the weaknesses of this collaboration for you?

Participant D mentioned that one strength of their collaboration was to share what worked and did not work with new lessons. For example, she said that if something did not work as planned during her first period lesson, she could share that information with Participant C so that she could make changes to the lesson before she needed to teach the lesson herself. This also applied to technical problems. If Participant D ran into a

technical problem with the IWB, she could request to get it fixed before Participant C needed to use it during the second-half of the school day. She did not mention any weaknesses about their collaboration.

Question 12: Are you looking for any particular kind of information in relation to this collaboration?

Participant D responded with a "no" to this question. She said they were "just trying to do what [was] best for the kids. It's the only reason we work together, to find out what works best for one of us." She mentioned how they shared activities that had been proven to be fun and educational for their students.

Question 13: When you talk to others about your collaboration, what do you share with them?

Participant D said she was "kind of in an odd predicament" as a part-time employee. She did not see other teachers very often, so she has not talked to anyone about her collaboration. She said she felt "isolated."

Question 14: Have you done any formal or informal evaluation of how your collaboration is working?

Participant D said that informally, she could tell from her student's AP exam scores that her collaboration had made her a better teacher. She thought that her collaboration had been beneficial for her because it had allowed her to address areas of weakness in her own methods and lesson plans. However, she had not done any formal evaluation of the collaboration.

Question 15: What plans do you have for this collaborative effort in the future?

Participant D said she had no plans for the collaborative effort in the future, but that she hoped it continued. She felt that "it does work when two or more people work together. The teamwork can benefit the child more than anything else we do."

Question 16: Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Participant D indicated that she considered herself a "novice" IWB user. She thought there was "a lot out there" that she could be doing with her IWB that she did not know about, nor had the time to learn on her own. She said she needed more training in order to expand her abilities with her IWB.

Participant E

Question 1: Are you using the innovation?

Participant E responded that yes, she used her IWB "every single day." She added, "I love it."

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

For strengths of IWBs, Participant E mentioned the ability to pull up a virtual graphing calculator on the screen so that she could show students "how the keystrokes go." She also found benefit in the ability to copy-and-paste the graphing calculator's output screen so that it could be enlarged, making graphs "big enough for [students] to see" and allowed her to annotate them with her stylus. She also liked the ability to save

her classroom notes on-line. She summarized by saying that IWBs had "just a lot of strengths, a lot of things that are helpful for the students."

Regarding weaknesses, participant E said that "students sometimes are intimidated to go to the board and work on the SMART Board themselves because other kids kind of think it's funny and so on." She said that if a student laughed at another student while using the IWB, she made the offending student go up to work on the IWB next "to let them experience it." She did this not so much as punishment but as a way to get more of her students to personally experience what it was like to use an IWB. She said that "you do have to experience it, how to write on it, and stuff like that." Without that experience, she thought it was harder for students to appreciate the nuances and difficulty of using an IWB.

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Participant E said that she looked for more information about IWBs while on vacations from school. During these breaks, she said she uses the Internet to search for "interactive programs that [she] can use on the computer, either for the kids to come up there and do, or for [her] to show them how certain math concepts relate to the world." She was trying to find ways to get her students more involved with the IWB and find ways to get more out of it.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant E said she talked to "people who ask" her about the IWB. She let teachers know that she was willing to teach them how to use the IWB if they were interested and wanted to learn about it. She also offered to let other teachers use her classroom in order to get access to an IWB if they wanted to use it for a lesson.

Participant E also told people about the ability to post IWB classroom notes on-line. She told people "how helpful it is for the students because they can go on-line and see what they missed." She mentioned that "some kids are very careful about copying the notes down, so they can go on-line and check and make sure that what they wrote down in class is in their notes." She also mentioned that students who were absent "can go on-line and copy the notes and figure out what they missed."

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Participant E said that one of the effects of using an IWB was that it "makes note-taking so much easier." For example, she used prepared word-processed notes and mathematics problems to pull up on her IWB screen in order to work them out in class using a stylus. She also referred back to her earlier response about the advantages of saving notes on-line.

She admired the ability to enhance note-taking so much that she said she "really would like to learn how to use the video" function of her IWB. The video function allows IWB users to record in real-time everything that occurs on the screen. If a microphone is attached, voices and sounds can also be recorded in sync with the video. The effect is essentially a permanent record of what was said, written, and shown in class. This file could then be saved on-line. Participant E would like to do this for her students, but was concerned that "the files [would be] really large and you have to have a place where you can save them."

As far as evaluations were concerned, Participant E said that she typically just reflected on what she did each day: "What went well? What didn't go well? What can [she] do to make it go better? Is there something [she] can look for on-line to make it a better lesson?" Aside from these informal evaluations of her performances with her IWB, she had not done any formal evaluations of herself.

Regarding student feedback about her IWB, Participant E said that she gets "some feedback about it." She noted that "they love that they can go and access the notes on-line." From a negative standpoint, students have shared with her that some of them "don't feel comfortable writing on the SMART Board." As a result, when she calls students up to the board, she allowed them to work mathematics problems on the "regular whiteboard" if they are uncomfortable writing on the IWB. She said that she does not ever "force them" to use the IWB, but rather just wants "to make sure they can do the work."

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

Participant E said she had recently started to use the copy-and-paste function more to isolate and enlarge her virtual graphing calculator's output screen. She said this function was necessary because she was unable to write on the IWB screen when the virtual graphing calculator was displayed. As soon as she touched the screen, the calculator disappeared. Therefore, in order to annotate the output of the calculator, she had to copy-and-paste the results into a document that could be written on with the IWB stylus.

Participant E mentioned another change that she had made to her IWB usage during the last school year. Using her own funds, she had purchased a writing tablet input device that allowed her to manipulate the displayed screen on her IWB. This way, she was "not in the way of [her] shadow and not in the way of students, ever, being able to see." Using an IWB stylus typically requires having one's back turned to at least part of a class. By writing on the tablet input device from across the room, Participant E said she was able to "watch the students a lot more closely" which lead to "less discipline problems."

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

Participant E knew that she was scheduled to teach Integrated Geometry in the upcoming semester, which involved many lessons about circles, so she planned to go on-line over the winter break and search for "programs and/or different activities" for her

IWB. She stated that her goal was to “enhance [student] learning and hopefully help them get the information” about circles.

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

At the time of this interview, Participant E said she was not working with anyone else about IWBs. She had asked others if they would be interested in collaborating with her. Unfortunately, she said that due to time constraints, no one had accepted her offer to collaborate about IWB issues.

In the past, Participant E said that when she first got her IWB a few years prior to this interview, the three teachers with IWBs at the school helped each other create “notes and warm-up activities...all kinds of different things that [they] could use on the SMART Board.” Now that they had “established” themselves, she said that they no longer felt the need to collaborate together.

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

Participant E said that the only modification that she would like made to her IWB setup would be to have her LCD projector installed on the ceiling. She said that this would help alleviate the shadows that were created whenever she got between the projector's output and the IWB's screen itself, which made her unable to see what she was writing on the digital display.

Question 10: How do you work together? How frequently?

Participant E said that when she collaborated, especially at the beginning, she used to collaborate "almost daily" with the only two other IWB users at the school. Their collaboration meant that they shared notes, other documents, and ideas on how to best use their IWBs. She said that once they became established, they started to collaborate less and less. They simply began emailing each other documents that might be worthwhile to share. Since one of her original collaborators left the education field and the other no longer shared a common teaching assignment with her, she no longer collaborated with anyone about IWB issues, although she has sought to find new potential collaborators to no avail.

Question 11: What are the strengths and the weaknesses of this collaboration for you?

Participant E said that "at the very beginning, it was very useful because [they] took turns creating the lesson plans rather than everybody creating their own lesson-plans and the notes that [they] would present to the students." She said that it "saved [them all] a lot of time" since there were three people collaborating.

She said that the only weakness was that each of the collaborators "had a little bit of different approach with how to create a lesson". Therefore, she would have to tweak the lessons created by her collaborators to make it match her preferences. She said that this was a minor problem, though, and that collaboration was "still better" than having to build new lessons from scratch.

Question 12: Are you looking for any particular kind of information in relation to this collaboration?

Participant E said that when she was collaborating, she was just trying to find out ways to use her IWB. All three of the collaborators attended a summer workshop that was administered by the county for which they worked, but they knew there was a lot more that they could learn to do with their IWBs. Unfortunately, they never found the time to follow through on their ideas.

Question 13: When you talk to others about your collaboration, what do you share with them?

Participant E said that she mostly tried to share with others her word-processed lesson notes. She also gave others some tips on how to convert documents for easier use on the IWB. She also encouraged others to use a virtual graphing calculator and other tools in conjunction with the IWB software.

Question 14: Have you done any formal or informal evaluation of how your collaboration is working?

Participant E said no, she had not done any formal evaluations. However, she explained that she had routinely self-reflected "every day, at the end of the day, for the last 20 years." She has always tried to figure out what worked and what did not and how she could improve her performance. She just did not do this type of evaluation within the context of her collaboration.

Question 15: What plans do you have for this collaborative effort in the future?

Participant E said she "would love to have a collaborative effort in the new curriculum." She had talked to some of the teachers that had already taught a course in the new curriculum to see if they had any materials that she could use. That way, she would not have to "totally recreate the stuff." She said she would be "more than happy" to share any materials that she had already created, as well.

Question 16: Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Participant E said she used her IWB "constantly." Even though she has had a lot of experience with her IWB, she said that she "keep[s] trying to learn new things." For example, she had recently learned some new ways to change the colors of her stylus "ink" as she wrote on her IWB screen, which she said "saves a lot of time" while she is teaching. She had also recently learned how to change the thickness of her stylus writing since the default setting was "really thick." Learning how to change the thickness setting of her stylus had been useful in her Trigonometry classes because the thick writing would often not allow her to fit written answers into the tight spaces of some trigonometry problems. Overall, to summarize her thoughts on IWBs, she said, "I don't know how I would be able to go to a classroom without one. I would definitely have to rethink and redo a whole bunch of different stuff."

Participant F

Question 1: Are you using the innovation?

Participant F said yes, he used his SMART Board "every day" in order to teach lessons and perform assessments. He was the only participant to mention using his IWB for assessment purposes as an answer to this question.

Question 2: What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?

Regarding the strengths of IWBs, Participant F said that one strength was that "it provides kids with all the information that they wouldn't be able to take home with them, such as notes." He also mentioned that students who are absent can gain benefit from IWB use. These students were able to "go back and see what [he and his class] talked about."

As far as weaknesses were concerned, Participant F mentioned the time required "to make everything happen from a teacher standpoint." He said that IWBs were "great" from a student perspective, but "timing and preparing" were issues for teachers. He said it was time consuming just "making sure you have...all the system set up."

He indicated that his colleagues next door (namely Participant A and her team teacher) had a "better" IWB setup than himself. Their setup involved having two classrooms combined into one large classroom via a removable wall, thus allowing students to sit and face two Promethean boards with two whiteboards on the walls to their left and right. Each Promethean board in this room also had an arm extending out over the top of the board which has an LCD projector installed at the end of it. This alleviated

the common complaint from IWB users who must frequently recalibrate their IWB every time the LCD projector gets bumped. Given such an arrangement, Participant F said that his colleagues were "better" able to overcome some of the weaknesses associated with the IWB in his own classroom.

Question 3: Are you currently looking for any information about the innovation? What kind? For what purpose?

Participant F answered this question by saying, "Not really." He said he "pretty much" had everything he needed and had his IWB set up the way he liked it. The only thing he wanted were speakers for his IWB. The Promethean boards next door had built-in speakers, so Participant A and her team teacher were able to present multi-media clips to their students with sound. Having collaborated with Participant A and her team teacher, Participant F had personally experienced the benefits of adding sound capabilities to an IWB. This exposure made him want to replicate the same capability with his own IWB.

Question 4: Do you ever talk with others about the innovation? What do you tell them?

Participant F answered affirmatively to this question. He explained that he told other teachers about "all the different ways we use [IWBs]." He said that he spoke to both first-year IWB users and IWB users with longer periods of experience.

Question 5: What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?

Participant F said that one of the "huge" effects of using an IWB was that "parents can almost enter the classroom" now. He explained that by publishing his IWB class notes on-line, parents "can see what has transpired in class, what [teachers and students] have written in class." He said that parents still miss out on the verbal communication that ensues during a class period, but their IWB-enabled ability to see what was written and taught in class was remarkable to him.

Regarding formal evaluations, Participant F said that he had not done anything of the sort, although he did ask students for their feedback. He said his students "basically...just want to write on [the IWB]." As a result, he does not think that his students "really understand the significance of being able to do what [an IWB] does." For them, the ability to use the Internet in class was "not that big a deal."

Question 6: Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?

Participant F said that he had "made many changes over the years." He explained that when he first got his IWB, he tried experimenting with the recording feature, but he was still trying to maximize his efficiency with it. His goal was to pre-record lessons so that he could run it during class and walk around helping students with the material.

He had also “changed the set up of the room” so he could be out of students' lines of sight to the IWB. When Participant F received his first IWB almost four years prior to this interview, he was located in a different classroom. In that room, his IWB was installed on top of the whiteboard, limiting the amount of room he had to write. Due to the siphoning of students and teachers to a newly-opened high school down the road, Participant F was able to move into a new classroom right next door to Participant A and her team teacher. This allowed him to easily collaborate with these first-time IWB users and mentor them. In addition, since the IWB remained in his old classroom (which had since become occupied by the beginner IWB user profiled in the pilot study), the mathematics department purchased a new IWB for Participant F's new classroom. Based on his experience in his old room and the knowledge of Participant A's IWB layout, Participant F made sure that his new IWB was installed on a wall that did not already have a whiteboard on it. This has provided him with more room on which to write.

Question 7: As you look ahead to later this year, what plans do you have in relation to your use of the innovation?

Participant F said that he was definitely going to continue his efforts with the recording function of his IWB. He wanted to “enhance” the experience and set up speakers to go with his IWB. That way, he said that his IWB “can sound good and be useful.”

Question 8: Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?

Participant F said that his interactions with other IWB users mostly entailed them coming to ask him questions about it. He noted that some users had "done their own little stuff with [their IWBs], stuff that [he has not] done." He attributed this to users figuring out what works best for themselves, and that there was no one set approach to using an IWB. He said that he had not made any changes to his "process" based on what other users have done.

Question 9: Are you considering making or planning to make major modifications or to replace the innovation at this time?

Participant F planned to keep using his IWB. He said he was "still tweaking it" and improving the resources that he used in conjunction with his IWB. He did not plan to make any major modifications to his IWB usage or replace his IWB.

Question 10: How do you work together? How frequently?

Participant F said that he planned "together every day" with Participant A and her team teacher. He also met with other mathematics teachers who taught the same courses as he did on an "every other week" basis. He felt that they "work well together," especially Participant A and her team teacher, with whom he shared IWB resources so that they all conduct similar lessons together.

Question 11: What are the strengths and the weaknesses of this collaboration for you?

Participant F said that one of the strengths of collaborating was that it reduced "preparing time." With three teachers working so closely together, they could each take a third of the workload. Thus, there was no duplication of effort.

Regarding weaknesses of the collaboration, Participant F discussed the trouble caused by having two different brands of IWBs. He said that it was initially easy to share files across the platforms, but Participant A and her team teacher had received a software upgrade to their Promethean boards that complicated the sharing process. The Inspire Edition software no longer allowed him to easily convert material produced with it for his SMART Board.

Question 12: Are you looking for any particular kind of information in relation to this collaboration?

Participant F said no to this question. He said he was more interested in learning how to improve his students' interaction with the IWB. He thought most IWBs were only being used "kind of like an overhead projector basically." Participant F believed that once teachers started learning how to use their IWBs and became more efficient in their preparation, the functional advantages provided by IWBs would have a greater effect in the classroom.

Question 13: When you talk to others about your collaboration, what do you share with them?

Participant F said he told others what it was like to work with the other two teachers so closely. He described to others "how nice it is" to share information about students with his collaborating teachers since they teach many of the same students. Their arrangement involved moving students around across classrooms in order to provide remedial instruction or enrichment as required. Since all three teachers spent time with every student, they were able to share information about each student's strengths and weaknesses in mathematics, behavior, and other pertinent attributes.

Question 14: Have you done any formal or informal evaluation of how your collaboration is working?

Participant F said he had not done any formal evaluations concerning his collaborations. However, he had informally compared "how kids were doing in different scenarios with our collaboration" with his collaborating teachers. These informal evaluations were done to see how students were performing in different situations with different teachers and adjust accordingly

Question 15: What plans do you have for this collaborative effort in the future?

Participant F said that he wanted his collaborative arrangement to extend "department wide." He wanted his collaboration to include more teachers because it "opens the door to many things." He thought that expanding his type of collaboration would help "the teachers as well as the students." This would be due, in part, to the flexibility that such an arrangement would provide.

Question 16: Can you summarize for me where you see yourself right now in relation to the use of the innovation?

Participant F said that he would classify himself as “an expert,” or, as he half-jokingly asked, “what's higher than an expert?” He said that a computer programmer might be able to do more with an IWB, but he felt he could use an IWB as well as any educator could. He knew how to manage all “the little things” that go with using an IWB that often cause problems for new users.

APPENDIX I
INDIVIDUAL LOU RATING SHEETS

Adapted from Hall, Dirksen, and George (2006)

Participant A - LoU Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

Participant B - LoU Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

Participant C - LoU Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

Participant D - LoU Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

Participant E - LoU Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

Participant F - LoU Rating Sheet

Level	Knowledge	Acquiring Information	Sharing	Assessing	Planning	Status Reporting	Performing	Overall LoU
Nonuse	0	0	0	0	0	0	0	0
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	ND
No information in interview:	NI	NI	NI	NI	NI	NI	NI	NI

APPENDIX J

MODEL LESSONS FOR EACH GMAD CLASSIFICATION

Adapted from the guidelines of Glover, Miller, Averis, and Door (2007)

Supported Didactic

A Supported Didactic lesson involves the IWB, but it is not always a central part of the lesson. The teacher often writes on the whiteboard to supplement information on the IWB screen instead of writing on the IWB, which would allow the notes to be saved for future reference. The IWB is used in a basic fashion, such as displaying static information like an overhead projector, which limits the impact of the technology's capabilities. No consideration is shown for IWB-unique techniques, such as the circle-erase function to erase a lot of marks.

Interactive

The Interactive lesson improves on the Supported Didactic lesson by taking greater advantage of an IWB's capabilities. Instead of annotating notes on top of a Microsoft Word document, for example, the user annotates notes in the IWB word-processor program, which allows notes to be saved for later reference by the teacher or students. Other software, like Fathom or Geometer's Sketchpad, is used in conjunction with the IWB to better illustrate concepts. Students are encouraged to use the IWB themselves, but such interaction is not integral to the lesson. While the IWB is the focal

point of the lesson, older technologies may be used with it that could be replaced by the IWB. For example, a graphing calculator's output could be displayed using an overhead projector when the IWB could display the same information more clearly.

Enhanced Interactivity

The Enhanced Interactivity lesson takes full advantage of an IWB's capabilities at every opportunity, making it essential to the lesson. The IWB is used to present information in a compelling fashion that would be impossible to duplicate without the technology. Notes and annotations from the lesson are created on the IWB's word processor program, allowing them to be saved for later reference. Student interaction is an important aspect of the lesson. Students are able to access the IWB or files created with it either during or after class. Different software is used as needed to create a rich multimedia environment. The lesson was constructed via collaboration with other teachers, improving the product for students to maximize learning and enjoyment.

APPENDIX K

VIDEO-RECORDED LESSON ANALYSES

Participant A

In the first lesson, Participant A used her IWB to display some mathematics problems that students had done for homework the previous evening. The lesson was intended as a final review before an assessment that the students would take the following day. The topic was about circles: finding circumference, area, chord lengths, arc lengths, and angle measures inside and outside circles. The problems were from a professionally produced worksheet, but she had divided the worksheet into multiple "pages" on her IWB screen using a cut-and-paste maneuver. Thus, she was able to display only a few problems at a time and quickly flip between pages to display new problems.

Participant A worked each problem out on the IWB using the stylus, explaining each step as she went. Students were free to ask questions and provide answers at any time. Between the first and second problem, she asked students, "Is there a shout out for a color?" When one student responded with "purple," Participant A switched her stylus ink color to purple. She switched colors between every problem, helping students to differentiate each problem from neighboring problems.

One memorable incident occurred approximately 22 minutes into the lesson, when Participant A again asked for student input into her stylus ink color. Responses playfully ranged from "yellow" to "cyan" to "white". Since the worksheet problems were displayed in black ink on a white background, the lighter colors would obviously not be readable to students. Participant A chose cyan for her color, then tested it by scribbling

underneath a problem. When it proved to be too difficult to see, she tapped on the IWB menu to fill the screen background with a color other than white. The problems themselves, since they were cut-and-pasted as a single rectangular region, remained in black ink on a white background. The rest of the screen eventually became a dark gray color, enabling her to write in cyan and still be visible to students. She asked, "Now can you see it?" When students responded affirmatively, she asked again, "Does that make you happy?" When students again responded affirmatively, she said, "All right! Anything for you, [student name]." She later switched her color to yellow to satisfy a different student. Photo 1 depicts the problems on the gray background with cyan and yellow writing.

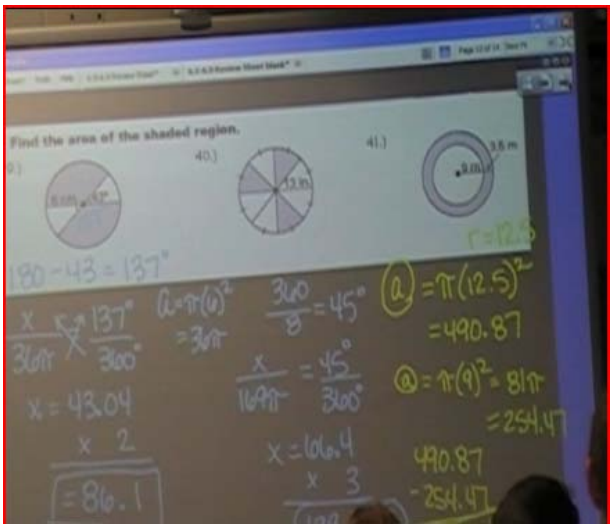

Photo 1. Problems on gray background with cyan and yellow writing.

At the end of the review lesson, Participant A pulled up a menu on the left side of the screen. She was able to scroll through all the pages she had already displayed and

pick out certain problems that she wanted to emphasize. The work that she had done previously had automatically saved to the pages, so all of her work was still visible on each page. At the end, she pulled up a different document with all of the work and answers to every problem already completed. She then announced to the class that students could come up to the IWB and toggle between the pages to see any problem that they wanted in order to help them prepare for the next day's assessment.

Her review time using the IWB lasted for approximately 35 minutes of the 52 minute class period. Pedagogical strategies observed were: compare/contrast problems, modeling, and student interaction. Using the GMAD classifications, Participant A was classified at the Interactive level for this lesson. This classification was chosen "because the IWB [was] used to challenge pupils to think by using a variety of verbal, visual and kinaesthetic [sic] stimuli" (Glover, Miller, Door, & Averis, 2007, p. 9). Participant A demonstrated a high level of knowledge about her IWB's capabilities, able to switch ink and even background colors to accommodate student learning and interest. Allowing students to use the IWB to review saved notes also demonstrated a high comfort level with the technology and an appreciation for its unique capabilities of saving class notes. If Participant A had used other media, such as Geometer's Sketchpad (GSP), to enhance the review, she would have been classified at the highest level, Enhanced Interactivity.

Participant A's second lesson was recorded more than one month later. The lesson presented new material to students and was entitled, "How do you write complex numbers?" It involved simplifying square roots into both real and imaginary numbers. The lesson began with pre-typed vocabulary words and definitions. The screen depicted

some animated .gifs (such as a sniffing dog and question marks with blinking eyes) that added movement and color to the screen but were unrelated to the material. She used the highlighter function of her IWB to highlight important parts of definitions in yellow. After allowing time for students to take notes of the definitions, she switched pages to display four example problems. She asked for student input as she worked each problem on the board. She then displayed some new problems for students to try on their own at their desks. Later, she allowed two students to come up and work out problems on the IWB themselves. At the end of the lesson, Participant A used some unique IWB functions. She drew a yellow star next to each answer and then grouped her work and the star together. She then clicked-and-dragged the work and star to the left side of the screen so that only the star was visible. To see the work again, one would only need to click-and-drag the star back to the right. By doing this, Participant A's work was not erased, but it was not visible unless desired.

Participant A said she used a program called Animation Factory to add the animated .gifs to her pages. The students seemed to enjoy seeing each new .gif as the pages were changed and commented favorably about them. One .gif depicted a girl (whom Participant A named Susie) doing homework on a floor. Noticing Susie's Pippi Longstocking-like pigtails, one of Participant A's students, who was seated in front of the IWB and was visible in the recording, pulled her own hair up with her hands to mimic them. The animated .gifs provided movement and color to otherwise staid mathematics material.

The lesson lasted approximately 40 minutes, all of which was spent with the IWB as the focal point. Participant A demonstrated some new knowledge about her IWB in this lesson compared to the previous recording. She used the highlighter function, used the eraser function to erase material that was no longer needed, performed the "undo" function when the IWB errantly registered her writing, added .gifs to her pages, and used the grouping feature to hide answers. She also encouraged student interaction with the IWB by allowing two students to do problems on the IWB. Participant A's second lesson was therefore classified as Enhanced Interactivity because it involved multiple functions of the IWB, incorporated other computer programs, and featured students using the IWB themselves. As Glover, Miller, Averis, and Door (2007) describe, the Enhanced Interactivity classification reflects a "progression from the previous stage with a focus on using the technology as an integral part of most teaching in most lessons, and integrating concept and cognitive development in a way that exploits the interactive capacity of the technology" (p. 10).

After analyzing both lessons, Participant A was classified as being at the Enhanced Interactivity stage overall. She demonstrated substantial knowledge about IWB functions, shared resources with her team teacher, incorporated animations into her lessons, and encouraged students to use the IWB themselves. Her use of the IWB enhanced the lessons and took advantage of its unique capabilities, earning and keeping student interest in the lesson. It was unclear if student learning was enhanced by the IWB since the material could have been taught in a similar fashion similar by a teacher using a

whiteboard, but the demonstrated capabilities of the IWB at least sparked student motivation in the lesson itself.

Participant B

The first lesson of Participant B was recorded a day after Participant A's first recorded lesson. Since they taught the same class, the material covered was the same: circle area, circumference, chord lengths, arc lengths, and inside and outside angles. As with Participant A, the lesson was a review prior to an assessment.

One difference between the two Beginner IWB users was the way they displayed their mathematics problems on the board. Participant B chose to display the entire worksheet on his IWB using Microsoft Word, exactly matching the sheets that students had at their desks. In contrast, Participant A chose to cut-and-paste the worksheet into smaller pieces, allowing her to displayed groups of similar problems on different IWB pages. Neither approach was wrong, but Participant A demonstrated more knowledge about her IWB's capabilities with her decision. In addition, when she wrote her answers on her IWB, the information was automatically retained as she flipped between pages. Since Participant B worked his problems on top of the Microsoft Word document, his stylus writing would disappear every time he scrolled around the document. Therefore, his classwork was not saved for later reference. Photo 2 depicts Participant B’s IWB screen with stylus writing on top of a Word document.

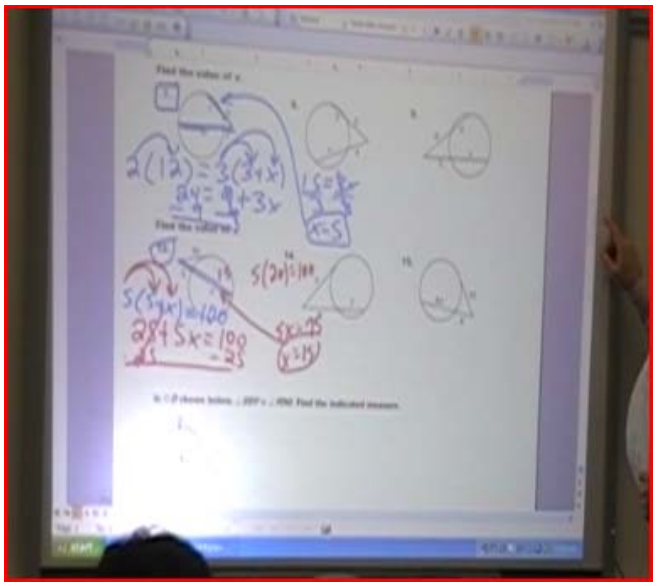

Photo 2. Writing on top of a Word document in different colors.

The lesson primarily involved Participant B working mathematics problems step by step on the IWB in different colors (Photo 2). Students were welcome to ask questions and provide answers at each step. In this lesson, Participant B demonstrated the following knowledge about IWBs: writing with the stylus, changing ink colors to differentiate work from neighboring problems, using the eraser to erase writing, and using files in other programs. His lesson was classified at the Supported Didactic level, meaning his approach was "characterised by the teacher making some use of the IWB but only as a visual support to the lesson and not as an integral strategy for conceptual development" (Glover, Miller, Averis, & Door, 2007, p. 9). His approach, while it certainly met the objectives of his review lesson, did not take advantage of very many IWB capabilities.

The second lesson, recorded more than a month later, was new material for students. It began with vocabulary words and definitions, which were pre-typed and displayed using Microsoft Word. Using one of the functions of his IWB, Participant B used a pull-down screen to hide words and definitions until later in the lesson, isolating a single definition at a time to help students focus.

The first concept he defined in the lesson was “distance from a point to a line.” To illustrate the concept, he copied a blank graph from another file and pasted it into an IWB document. On the graph, he used his stylus to draw a line and a point. He then called a student up to the IWB to draw “the shortest distance” between the point and the line. After drawing the segment, the student went back to her seat and Participant B elaborated on what she drew. He discussed how the segment drawn by the student was indeed the shortest possible length and that it was perpendicular to the line.

Later on in the lesson, Participant B defined what a transversal was. While the definition was displayed on the screen, he used a dry-erase marker to draw lines on the whiteboard next to his IWB and asked students to identify the transversal. By using both boards, he was able to utilize more screen space to illustrate and define the concept. He did this with other concepts in the lesson, as well.

Participant B's second lesson demonstrated the following IWB techniques: using a pull-down screen, cutting-and-pasting graphs, and switching between programs. He also invited a student to write on the IWB to illustrate a concept and he used the whiteboard to complement material displayed on the IWB. Glover, Miller, Averis, and Door (2007) described a similar situation in their observations:

> Occasionally teachers reverted to the use of conventional approaches to ensure cognitive development and there was evidence of lack of confidence in the technology or its teaching power. At these times teachers frequently made use of adjoining non-IWBs. The IWB was no longer a novelty to the pupils, and was integrated into teaching and learning but its full potential had not been developed. (pp. 9-10)

This description was used to exemplify the Interactive classification, so Participant B's second lesson was classified as Interactive.

Examined together, Participant B's lessons indicated that he was at the Interactive classification overall. He showed some understanding of his IWB's capabilities, but he did not teach his lessons entirely with the IWB, nor did he use his IWB as efficiently as he could have. For example, he did not appear to know that he could save his stylus writing if he wrote on the IWB software instead of writing on top of a Microsoft Word document. He still used his IWB to teach the lesson effectively, but more advanced users would likely have saved the class notes, either as an aid for absent students or as a reference in later lessons.

Participant C

The first lesson began with a review of piecewise functions in an AP Statistics class. Participant C displayed a question involving an absolute value function and asked students to describe all pertinent information about the function. She used different color ink to fill in their answers, including the graph. She then told them to check their work using a graphing calculator. She used an overhead projector to display a graphing

calculator's output on the whiteboard next to the IWB (Photo 3). Looking at the graph's table, she verified with the class that their plotted graph was correct.

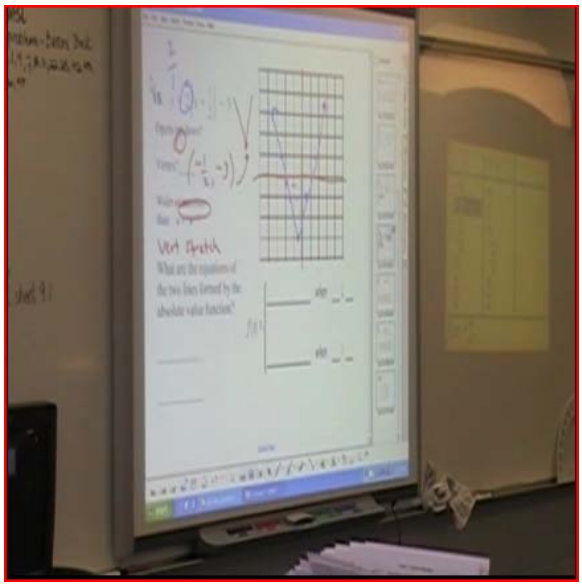

Photo 3. Overhead projection of graphing calculator output next to IWB.

When the problem was completed, Participant C tapped the IWB and brought up a new problem. Her problems were on separate page of the IWB software, so she and her students would be able to go back and see her work. The different IWB pages are visible in Photo 3 on the right side of the IWB screen. The lesson was classified as Interactive because the IWB was a central focus of the lesson, but it was supplemented with older technology that could have been done with the IWB.

In the second lesson, Participant C went over a quiz that her students had just taken in a previous lesson. She displayed the quiz as a Word document on the IWB screen and wrote answers to each question with her stylus. Since she wrote on top of the

Word document, her writing would disappear every time she had to scroll up or down. Thus, she was not able to save her answers onto the document for later reference by students. After the review, she covered some new material with the IWB word processor program. It was unclear if the notes she wrote were saved for later reference. Although the lesson itself was conducted entirely on the IWB, it did not involve anything more than displaying words and numbers from documents. Thus, the lesson was classified as Supported Didactic.

Participant C's lessons involved the following IWB techniques: displaying problems on separate IWB pages, displaying a Word document, using different color stylus ink to differentiate work, and using an overhead projector to supplement the IWB. Her pedagogical techniques included modeling problems and eliciting student responses. While the IWB was used as a visual tool alone, it was the focal point for both lessons. Participant C appeared familiar and comfortable with the IWB functions that were used in the lessons. However, her use of the graphing calculator on the overhead projector indicated that she was unaware of an IWB's capability to display a graphing calculator. Overall, her lessons classified Participant C's in the Interactive category.

Participant D

In the first lesson, Participant D displayed statistical data using a program called Fathom (Photo 4). As she discussed the information on the screen, she wrote numbers and calculations on her whiteboard. She did not write on the IWB with her stylus at all during the Fathom portion of her lesson.

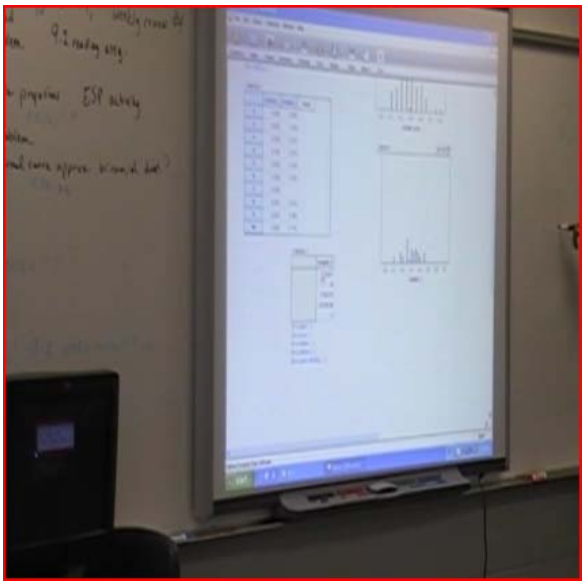

Photo 4. Displaying Fathom while writing on the whiteboard.

When she was done with Fathom, she went to the computer that was connected to the IWB and used the mouse to open a new program. This could have been accomplished using the IWB touch-screen, which indicated that Participant D was not aware of her IWB's capabilities or not comfortable using her IWB in this fashion. The new program she opened was the IWB word-processing program that allowed stylus writing to be saved. She had pre-typed notes in this document and annotated them with her stylus. She later invited a student to the IWB to work out a problem for the class.

On notable incident occurred when Participant D wanted to erase what she had written with her stylus. She picked up the IWB eraser and began erasing her "writing" as if it were a whiteboard (Photo 5). When the process took a few seconds of vigorous hand waving, a student told Participant D that she could have just circled the writing and

erased it using the IWB's erase function. Participant D said she was aware of that technique and used it occasionally, but she preferred to use the traditional erasing motions because it was a “habit” after her “many years” of using whiteboards.

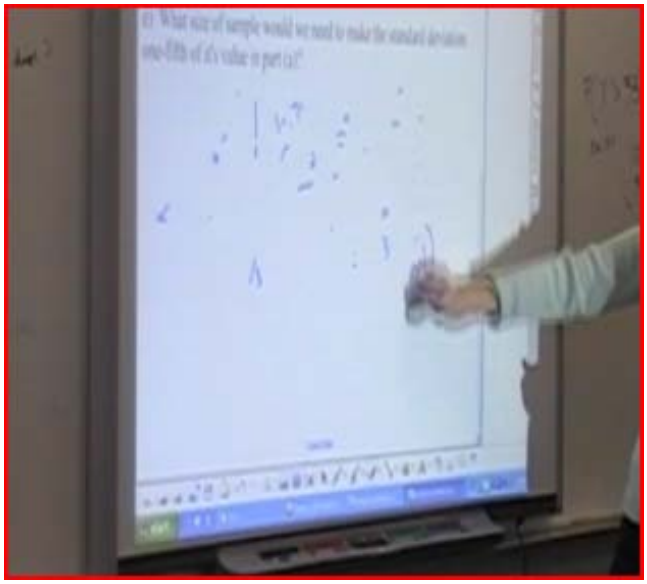

Photo 5. Erasing IWB writing with traditional hand movements.

Using the GMAD guidelines, this lesson would be in the Supported Didactic category since the lessons were “characterised by the teacher making some use of the IWB but only as a visual support to the lesson and not as an integral strategy for conceptual development” (Glover, Miller, Averis, and Door, 2007, p. 9). Because she relied on her whiteboard and did not demonstrate a high degree of comfort with the IWB, the first lesson was classified as Supported Didactic.

The second recorded lesson was very similar to the first lesson. Participant D used Fathom to display statistical data, the IWB word processor program to write notes

with her stylus, and randomly chose a student to work a problem on the IWB. When she needed to erase something this time, she pointedly used the IWB's circle-erase function instead of the traditional erasing movements in reference to her previous recorded lesson. One student commented how much faster it was and Participant D agreed. Another notable difference was that Participant D did not write on the whiteboard during the second lesson. Everything she wrote was done solely on the IWB, which perhaps indicated a growing comfort with the technology. Because she used multiple programs, encouraged student interaction with the IWB, and worked solely on the IWB, Participant D's second lesson was classified as Interactive.

Participant D's lessons involved the following IWB techniques: displaying Fathom software and annotating word processed notes with the stylus. Her pedagogical techniques included lecturing, modeling problems, and having students demonstrate work on the IWB. While Participant D used her IWB to display Fathom, it was mostly done as a visual support for the work she did off to the side using the whiteboard. She did use the IWB throughout each lesson, however, and did encourage students to use the board themselves. Overall, she was classified at the Interactive category.

Participant E

Participant E's first lesson involved series and sequences. She used the IWB's word processing program to display a variety of problems. This program allowed her to save her work for later reference. She used a tablet input device to control the cursor on the screen instead of standing up at the board and using a stylus. She used a virtual

graphing calculator to perform calculations, allowing students to see which buttons she pressed (Photo 6). The calculator displayed was a Texas Instruments TI-83+ calculator, which was the standard graphing calculator used among the school's mathematics teachers for most mathematics courses.

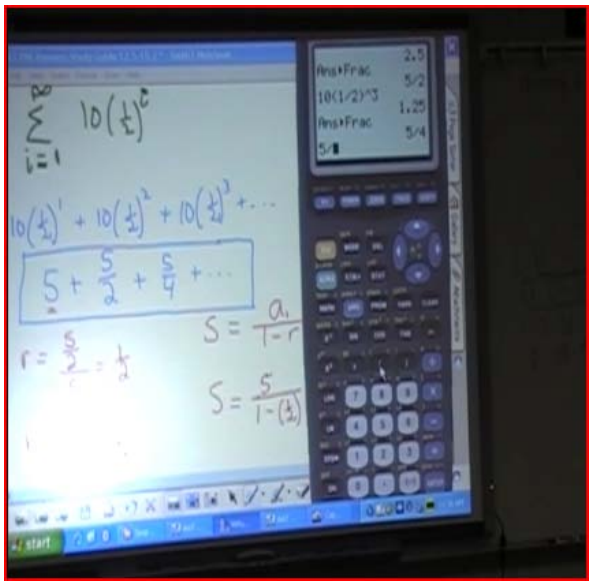

Photo 6. Using a virtual graphing calculator with a tablet input device.

Participant E exhibited a solid understanding of her IWB's capabilities. Not only did she use the virtual graphing calculator, but she knew how to copy-and-paste the calculator's output screen into the IWB word processor so she could annotate it and save it. She was also very proficient at changing ink colors, using the line function to create a straight line instead of drawing a straight line by hand, switching between pages, erasing unwanted marks, and saving her notes for later reference. Participant E's focus was “on using the technology as an integral part” of her lessons and “integrating concept and

cognitive development in a way that exploit[ed] the interactive capacity of the technology" (Glover, Miller, Averis, & Door, 2007, p. 10). Therefore, she was classified in the Enhanced Interactivity category.

The second lesson involved the unit circle. To supplement the lesson, Participant E had a large banner of a unit circle hanging next to her IWB (Photo 7). She also had it displayed on an IWB page, to which she frequently referenced during her lesson.

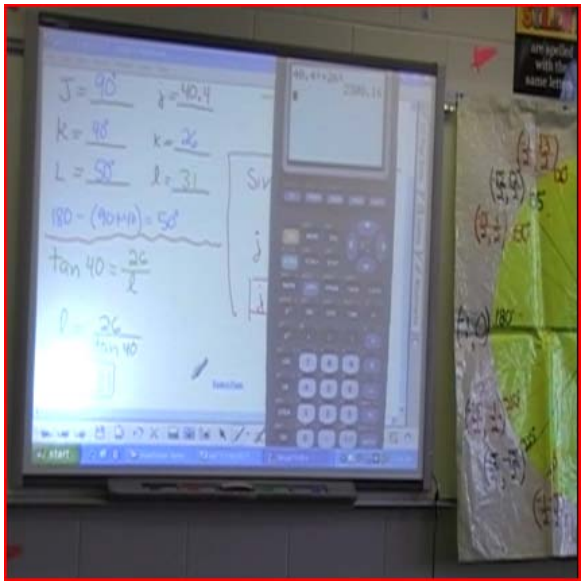

Photo 7. Unit circle banner next to IWB.

One notable difference in this lesson was student involvement with the IWB. Participant E invited a student to work a problem on the IWB, and it appeared to be the student's first time using the board. When the student caused an errant mark to appear on the IWB, Participant E instructed her to not let her hand touch the board and told her how to "undo" the mark.

The second lesson demonstrated the same level of skill with the IWB as the first lesson. The difference was student interaction, which suggests a higher level of confidence with the technology. Therefore, the second lesson and Participant E overall were classified at the Enhanced Interactivity level.

Participant F

The first lesson began with a review of distribution and lead into a lesson about imaginary numbers. Participant F used a variety of ink styles, including dashed lines to show the FOIL process and the highlighter to emphasize key concepts, and colors to enliven the lesson. He also invited students to come up to the IWB to work out warm-up problems at the beginning of the lesson.

Everything was done on IWB word processor pages, so he was able to quickly reference previous problems and material as he taught the lesson. For example, he was able to copy-and-paste a note about "$i^2 = -1$" from a previous page onto a new problem and highlight it (Photo 8). One student audibly commented how "cool" the process was.

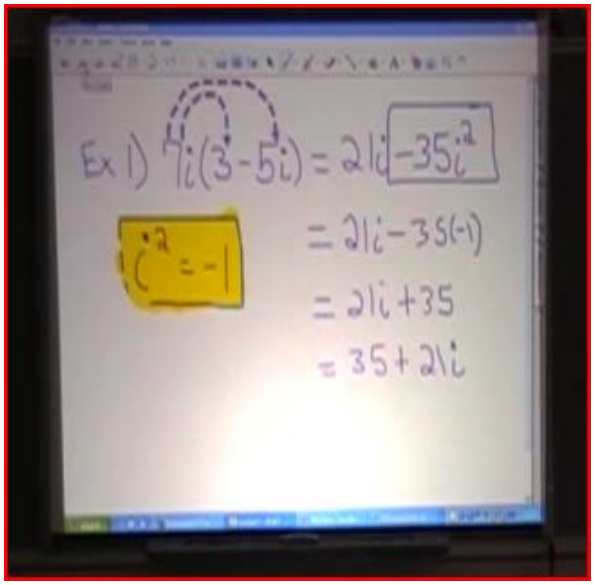

Photo 8. Different ink styles and colors with copy-and-pasted note highlighted.

Another interesting technique that Participant F demonstrated was having students work a given problem in their notebooks while he worked the problem in white ink on the board, effectively making his work invisible to students. When it was time to check student answers, he either highlighted his writing and changed the ink color to something dark so it was visible to students, or he changed the background color to something dark so the white writing was visible. At the end of the lesson, Participant F displayed a page from the student textbook, which was available in its entirety on-line. Students without a textbook could copy the problems down from the board if necessary.

The second lesson was more lecture-oriented at first. The lesson began with some pre-typed notes displayed with the IWB word-processor. The file was shared with Participant A, so some of the same characteristics that were seen in her second lesson

were seen in Participant F's lesson. For example, it included an animated .gif of a parabola being drawn. Participant F made some annotations to the notes as he lectured. The next page he showed was an example asking students to "Graph a function in the form $y=ax^2+c$" (Photo 9).

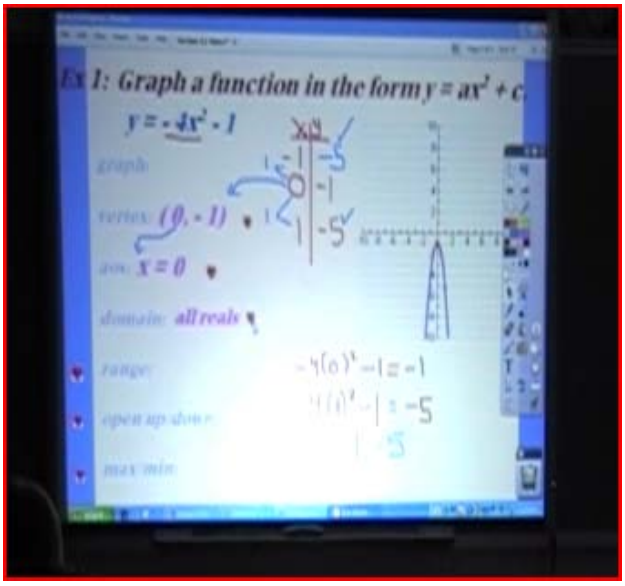

Photo 9. Answers hidden off-screen until dragged into view.

The answers to different parts of the example were hidden off-screen and were pulled into view when needed. Little heart symbols indicated where the answers were located, so Participant F clicked-and-dragged on a heart symbol to bring the associated answer into view. This was the same technique that Participant A used in her second lesson.

Participant F later used a virtual graphing calculator in his lesson, just like Participant E did. He demonstrated a variety of techniques with the graphing calculator,

enabling students to see which key strokes he was pressing. He displayed the on-line textbook next to his graphing calculator in order to do problems from the text.

Participant F demonstrated the following IWB techniques in his lessons: displaying notes over multiple pages, hiding notes off-screen until needed, using the virtual graphing calculator, displaying the on-line textbook, highlighting important concepts, changing stylus ink color and styles, displaying the on-line student textbook. His teaching techniques included lecturing, modeling, and student interaction with the IWB. He exhibited an expert ability to operate his IWB and used a variety of techniques to make the lesson more interesting for students. As such, both lessons, and Participant F overall, were classified as Enhanced Interactivity.

APPENDIX L

IWB TEACHER FOLLOW-UP QUESTIONS AND ANALYSES

Question 1: Were the video-recorded lessons representative of how you typically use your IWB?

All of the participants responded affirmatively to this question.

Question 2: How were they similar to other lessons involving your IWB?

The recorded lessons were mostly similar to the participants' typical IWB lessons. Participant A said the lessons were similar in that they emphasized note-taking and student practice. Participant B said the recorded lessons were similar, explaining that he often used his IWB like a whiteboard. He explained that since the recordings were made, he had learned how to use the IWB word-processor to display notes in class, allowing him to save his notes for later reference. Participant C said she typically used her IWB to facilitate note-taking by displaying pre-typed notes and examples. She mentioned that she often saved notes for students who were absent. Participant D said she typically used pre-typed notes and Fathom software in her lessons, and encouraged student involvement just as the recorded lessons demonstrated. Participant E said she used her pre-made notes in every lesson. Participant F referenced his use of multiple pages of notes, examples, and different colors and technologies to enliven his lessons.

Question 3: How were they different to other lessons involving your IWB?

Participants B, D, and E said the recorded lessons were not different from their typical IWB lessons. Participant A said that she usually invited students to use the IWB more often than was captured in the video-recorded lessons. She said that one of the

classes that was recorded tended to be quiet and introverted, so she had more difficulty getting them up to use the IWB. Participant C said she occasionally displayed an on-line textbook for her Integrated Geometry students or used the Fathom program for her AP Statistics students, neither of which she demonstrated in the two recorded lessons. Participant F said his lessons were usually more spontaneous, but the second recorded lesson captured his use of a file he obtained from Participant A.

Question 4: What pedagogical strategy/strategies did you use in the lessons?

The responses to this question were mostly consistent among all participants. Participant A said she tried to combine teacher lectures, note-taking, and student interaction with the IWB. Participant B said he used a combination of modeling, note-taking, and student practice. Participant C said her recorded lessons mostly involved note-taking and student problem solving. She said when she used Fathom, it was more of a "discovery" lesson for her students. Participant D mentioned lecturing, note-taking, and hands-on activities as her pedagogical strategies. Participant E would occasionally call students to the IWB, but mostly it was teacher-lead note-taking. Participant F relied on lecturing, note-taking, and student participation.

Question 5: Did you have any concerns regarding IWB use before, during, and/or after the lessons?

Participants B, E, and F said they had no concerns about IWB usage. For the others, concerns about the IWB were strictly technical. Participant A said her only concern involved technical glitches beyond her control. She provided a recent example in which her IWB would not turn on. She needed to get support from the school's

technical support personnel to fix the problem, which was stressful since she had planned to use the IWB for an upcoming observation. She realized how dependent she had become on the technology.

For Participant C and D, recalibration was the main concern. Participant C said the need to recalibrate often caused an "interruption" in her lessons. For Participant D, while recalibration was her "biggest concern," she also said that her IWB would occasionally "freeze" between classes, requiring her to restart the software.

Question 6: Do you have any other comments about IWBs?

The comments were mostly positive. Participant A said she loved her IWB and thought it would be a great tool for any teacher. Participant B said he enjoyed using his IWB and was getting to the point where he could not imagine teaching without one. Participant C said the IWB made lessons move faster and improved student motivation. Participant D said she wanted to learn more about her IWB because it was a "very useful tool" and she had not received any training. Participant E said she wished she had more time to do research for IWB lessons to make them more "hands-on" for students or more "real-world". In the second lesson, Participant F shared one of Participant A's files, which was created using her Promethean software. He commented that he was not able to fully use all of its functionality on his SMART Board, but he made it work the best he could.

APPENDIX M

PERMISSION LETTER FROM GEORGIA SOUTHERN UNIVERSITY

INSTITUTIONAL REVIEW BOARD

Georgia Southern University
Office of Research Services & Sponsored Programs

Institutional Review Board (IRB)

Phone: 912-478-0843
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Veazey Hall 2021
P.O. Box 8005
Statesboro, GA 30460

To: Jeffrey S. Hall

CC: Charles E. Patterson
Associate Vice President for Research

From: Office of Research Services and Sponsored Programs
Administrative Support Office for Research Oversight Committees
(IACUC/IBC/IRB)

Date: September 28, 2009

Subject: Status of Application for Approval to Utilize Human Subjects in Research

After a review of your proposed research project numbered **H10052** and titled **"Interactive Whiteboards and High School Mathematics Teachers: Case Studies of Change",** it appears that (1) the research subjects are at minimal risk, (2) appropriate safeguards are planned, and (3) the research activities involve only procedures which are allowable.

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that the Institutional Review Board has approved your proposed research.

This IRB approval is in effect for one year from the date of this letter. If at the end of that time, there have been no changes to the research protocol; you may request an extension of the approval period for an additional year. In the interim, please provide the IRB with any information concerning any significant adverse event, **whether or not it is believed to be related to the study**, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator **prior** to initiating any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, you are required to complete a *Research Study Termination* form to notify the IRB Coordinator, so your file may be closed.

Sincerely,

Eleanor Haynes

Eleanor Haynes
Compliance Officer

APPENDIX N

PARTICIPANT INFORMED CONSENT

Dear Participant,

My name is Jeff Hall and I am a graduate student at Georgia Southern University conducting dissertation research entitled *Interactive Whiteboards and High School Mathematics Teachers: Case Studies of Change.* The purpose of my study is to analyze teacher concerns regarding interactive whiteboard use in the high school mathematics classroom.

If you choose to voluntarily participate in this study, you will have the opportunity to participate in a pre-interview, a questionnaire, two video-recorded lessons, and a post-interview concerning interactive whiteboard use in the high school mathematics classroom. Each interview and questionnaire should last no longer than 15 minutes. Each video-recorded lesson will last no more than 50 minutes. Your participation in this study is completely voluntary. The risks from participating in this study are no more than would be encountered in everyday life; however, you may stop participating at any time without penalty. You may choose to skip any question(s) you do not wish to answer for any reason.

In order to protect your confidentiality, your name will not appear on any reports or be used in any presentation or publications resulting from this study. The video recordings and transcriptions will be stored on my password-protected personal computer and will be deleted three years after the completion of my dissertation. Only I will have access to these video tapes during the course of my research. If you have any questions or concerns regarding this study at any time, please feel free to contact me, Jeff Hall, via email at jeffrey_hall@gwinnett.k12.ga.us or my faculty advisor, Dr. Gregory Chamblee, Department of Teaching and Learning, Georgia Southern University, P.O. Box 8134, Statesboro, GA 30460, (912) 478-5701, gchamblee@georgiasouthern.edu. For questions concerning the process of the Institutional Review Board in reviewing all projects involving human subjects or for answers to questions about the rights of research participants, please contact the Office of Research Services and Sponsored Programs at Georgia Southern University, (912) 478-0843 or IRB@georgiasouthern.edu.

Thank you in advance for your help in studying this question. The results of this study should be beneficial to K-12 administrators and teachers who use interactive whiteboards. You will be given a copy of this consent form to keep for your records.

Sincerely,
Jeff Hall, Ed.D. Candidate
Georgia Southern University

You must be 18 years or old to participate in this research study. If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below.

_____ _____

Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

_____ _____

Investigator Signature Date