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Interactive Whiteboard Impact On Algebra Teachers' Implementation Of Selected Mathematics Teaching Practices

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INTERACTIVE WHITEBOARD IMPACT ON ALGEBRA TEACHERS' IMPLEMENTATION OF SELECTED MATHEMATICS TEACHING PRACTICES

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DEDICATION

I dedicate this to my daughters, Alaina Faith Hartman and Clara Grace Hartman. I love you.

ABSTRACT

This study investigated the use of the interactive white board (IWB) and the impact the technology had on mathematics teaching practices for algebra teachers. The study used the Technological Pedagogical Content Knowledge (TPACK) model as the conceptual framework for the investigation, collection, and analysis of data. Teachers were interviewed to obtain teacher level of IWB use, and the Mathematics Classroom Observation Protocol for Practices ($MCOP^2$) was used to obtain data for effective mathematics teaching practices. Observations of teachers were analyzed in order to answer the research question: *How does the use of an Interactive White Board impact an algebra teachers' implementation of selected mathematics teaching practices?* Findings from the study indicate the teachers most often used the IWB at the interactive level, followed by the enhanced interactive level, and least at the support didactic level. Posing purposeful questions and Using and Connecting Mathematical Representation were the most frequently used selected Mathematics Teaching Practices.

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LIST OF ABBREVIATIONS

EI……………………………………………………………..…Enhanced Interactive

I………………………………………………………………………………Interactive

IWB...Interactive White Board

MTP .... Mathematical Teaching Practices

NBCT..National Board Certified Teacher

Q……………………………………………………………..…………..Questioning

R/PL…………………………………………………………..…...Review/Prior Learning

S………………………………………………………………………………..Structure

SD……………………………………………………………...…………Support Didactic

SE…………………………………………………………………..Student Engagement

TF……………………………………………………………….…..Teacher Facilitation

VV…………………………………………………………………….…..Verbal Visual

CHAPTER ONE

INTRODUCTION

Background

Consider the following dialogue between two high school teachers discussing Interactive White Boards (IWBs) following a professional development session on technology.

Teacher X: Here we go again, throwing money into something that is no more than an expensive overhead projector. Sure, I created a couple of interactive lessons, but I could have accomplished that with worksheets. Everybody thinks the IWB is the goose that will lay the golden egg of instruction (*Teacher X's comments are followed by laugh)*.

Teacher Y: Come on, you digital dinosaur--walk into the light. This tool can take your teaching to a new level to help students learn.

The two viewpoints expressed by the teachers are diametrically opposed to each other and demonstrates the range of perceptions about IWBs. Whereas teachers' views about IWBs are mixed--some positive, some negative--most students seem to enjoy IWBs and other new technologies (Hall & Higgins, 2005). This sentiment is mirrored in my own classroom, exemplified in the following comments:

Alaina: I get it! I get it! I get it! I can see how the graph grows faster, and understand why in my mind. I get this exponential growth stuff. I am learning!

Clara: Seeing the bars getting taller in real time, helps it click in my head. How you use the smart board helps me learn algebra.

Although I am not suggesting that these students' views represent those of all students, their comments illustrate that the IWB can motivate and engage students in algebra classrooms. The IWB, also referred to by their brand names of Smart Boards or Promethean Boards, are presentation devices. The IWB is similar to a dry erase board – approximately four feet by four feet square that can be mounted to the wall – or can utilize a floor stand to be moved from various classrooms. The IWB is connected to a computer and a projector to facilitate the presentation of media content, display various software applications, web pages, documents, or material for learning. The central location of the IWB creates a student-centered learning environment, and the capability of the IWB software affords the teacher the ability to create dynamic interactive flipcharts. These dynamic interactive flip charts allow the teacher to create rich learning environments for the learning to take place (Armstrong et al., 2005; Glover & Miller, 2001; Glover, Miller, & Averis, 2003; Miller, Glover, & Averis, 2004).

Problem Statement

This section describes the problem addressed by the proposed study. IWBs are installed in mathematics classrooms with the expectation teachers will use them to create positive learning environments for meaningful mathematical learning. The use of IWBs in mathematics classrooms is widespread, yet little research exists which shows the impact of this technology on students' outcomes in algebra classrooms (Glover, Miller, Averis, & Door, 2005; Swan, Schenker, & Kratcoski, 2008). A significant body of research indicates the positive influence IWB use has upon student engagement, (De Vita, Verschaffel, & Elen, 2014; Holmes, 2009; Swan et al., 2008) motivation (Torff & Tirotta, 2010), and interactivity (H. J. Smith, Higgins, Wall, & Miller, 2005). Similarly, there is research to support the positive impact of IWB use for algebra instruction for the diverse levels of students in the algebra classroom (Wall, Higgins, & Smith, 2005). Even with positive indications in the literature supporting the IWB in the teaching and learning of algebra (De Vita et al., 2014; Glover et al., 2005; H. J. Smith et al., 2005; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011), how does the IWB impact effective mathematics teaching practices? In the National Council of Teachers of Mathematics, *Principles to Action* (2014), eight mathematics teaching practices are identified to provide an outline to support mathematics teaching and learning. These practices are: Establish mathematics goals to focus learning, implement tasks that promote reasoning and problem solving, use and connect mathematical representations, facilitate meaningful mathematical discourse, pose purposeful questions, build procedural fluency from conceptual understanding, support productive struggle in learning mathematics, and elicit and use evidence of student thinking. These practices, along with teachers' levels of IWB use is the focus of this proposal, answering the research question: How does the use of an IWB impact an algebra teacher's implementation of selected mathematics teaching practices?

Academic Performance of Students

Algebra serves as a gateway course to subsequent higher-level mathematics courses such as trigonometry and calculus (Atanda, 1999; Gulick & Scott, 2007; Moses & Cobb, 2001; Riley, 1998). Yet, students perform poorly on national algebra assessments and the South Carolina algebra course examinations (South Carolina Department of Education, 2015). This has consequences for students, teachers, schools, and districts, each whom are judged based on these tests scores (Baker et al., 2010). For example, a common practice is for students who perform poorly on the end-of-year examinations are subsequently unable to enroll in higher level mathematics courses (Spielhagen, 2006). This limits their opportunities to be admitted to many four-year colleges and also to have the background needed to work in disciplines, such as science, technology, and engineering (Schiller & Muller, 2003). Additionally, in terms of equity issues (Tate, 1994), students from lower socioeconomic backgrounds and students of color are less likely to do well as compared to their middle-income and white counterparts on such end-of-year examinations (Hemphill & Vanneman, 2011; Vanneman, Hamilton, Anderson, & Rahman, 2009). Hence, it is important to find ways to provide students with more comprehensive accessibility to mathematics courses. IWBs may be one innovation to provide support to teachers in the delivery of algebra content and aid students in meaningful mathematical learning opportunities.

IWB Use and Student Achievement

Schools have invested in newer technologies such as IWBs (Slay, Siebörger, & Hodgkinson-Williams, 2008) with the hopes of increasing engagement in algebra classrooms and student achievement (Moss et al., 2007); however, the impact of IWBs on student academic outcomes in algebra classrooms is not clear (De Vita et al., 2014). That is, the literature on the relationship between IWBs and student achievement is inconsistent (Bruce, McPherson, Sabeti, & Flynn, 2011; Glover et al., 2005), and contradictory (Sobel-Lojeski & Digregorio, 2009). The literature also includes a call for more research to investigate the relationship (Parks, 2013). For example, there is some research supporting claims that IWBs have a positive impact on student achievement (Nejem & Muhanna, 2014; Serin, 2015; Somekh et al., 2007), as well as studies which have found that they do not influence student learning outcomes (S. Higgins, Beauchamp, & Miller, 2007). Nejem and Muhanna (2014) used a pretest/posttest to compare teachers that used the IWB and those that did not use the IWB in order to measure the impact upon student achievement. Similarly, Serin (2015) investigated teacher use/no use of the IWB and student achievement by administering achievement tests over a six-week period to see the impact on student achievement. Studies by Nejem and Muhanna (2014) and Serin (2015) both concluded IWBs have a positive impact on student achievement. Even with the positive influence upon student achievement and IWB use, there is ambiguity in the manner in which teachers are using the IWB. Hence, more needs to be known about the circumstances under which teachers are using the IWBs. For instance, are IWBs more effective in some settings and courses than others? Are teachers using the full capabilities of the IWB?

Teacher Pedagogy with IWB

Glover et al. (2005) suggested the use of IWB in regards to pedagogy is still in its infancy, with little known about the methods teachers employ in using them in algebra classrooms. Some scholars have noted that teachers who use IWBs will require a paradigm shift in their pedagogical practices (Slay et al., 2008). Torff and Tirotta (2010) used a treatment/control study to determine that IWB use impacts student motivation in mathematics but found a weak effect and recommended that more research is needed in teacher use of IWB. Jang and Tsai (2012) investigated the use of the IWB by science and mathematics elementary teachers for the impact on their technological pedagogical and content knowledge. An IWB based TPACK questionnaire was utilized, and results indicated significant differences in elementary teachers TPACK for those using the IWB compared to those that did not. Türel and Johnson (2012) also used an IWB survey to investigate teacher perceptions of IWB usage in schools. Findings suggested teachers believe the use of the IWB does benefit teaching and learning, but teachers need more training to develop instructional strategies of using the IWB. Beauchamp and Kennewell (2013) found that professional learning is needed for teachers to deepen skills for using the IWB at a high level that can impact pedagogy. They analyzed two levels of teachers using the IWB: a basic stage and a sophisticated synergistic stage. The teachers using the IWB at the synergistic stage were illustrated by classrooms where the IWB was the hub for orchestrating activities in comparison to a static use of the IWB for teacher-led instruction. Findings suggest that there is a demand for developing skills to use the IWB in teacher training programs. Historically, teacher education paradigms have focused on content knowledge (Shulman, 1986; Veal & MaKinster, 1999), and pedagogical practices of the teacher (Ball & McDiarmid, 1989). Shulman (1986) contends pedagogical and content knowledge are not separable, but the intersection, and resulting interactions, of these two domains guide teacher actions within the classroom. The intersection of domains includes classroom management, planning, and time allocation, in conjunction with previously content-based training. Ball (2008) proposes teachers need to have deep mathematical knowledge for teaching, which is essential in the teaching of mathematics. More recently, the integration of technology is another component for consideration in teacher education. Mishra and Koehler (2006) investigated the incorporation of the technology in the classroom and the associated impact it has upon the pedagogy and content in the teaching and learning process. This resulted in the development of a model to explain the complex process and interaction, referred to as TPACK (Mishra & Koehler, 2006).

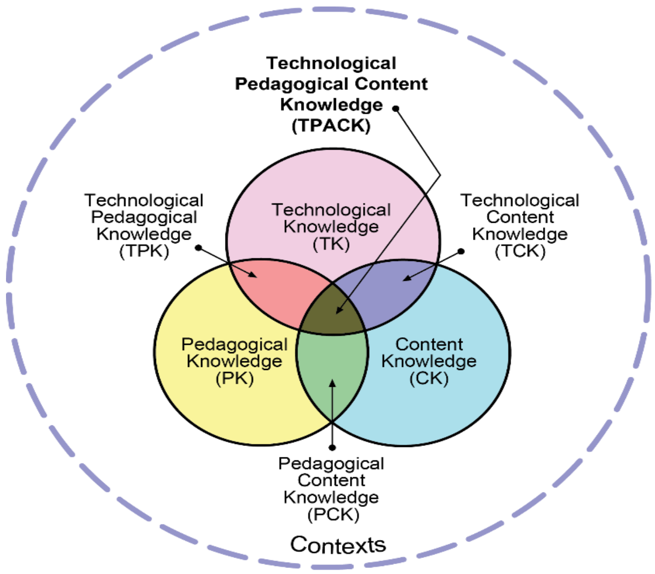

Figure 1.1 TPACK model

It is at the intersection of these three components (content, pedagogy, and technology), where the shift in teaching practices must take place (Slay et al., 2008). Mishra and Koehler (2006) assert that teachers who limit the use of IWBs to lectures, presentation of notes, and videos are not changing teaching practices to incorporate the full capabilities of IWBs. Contrastingly, incorporating the use of dynamic capabilities of IWBs, such as the ability to stretch and shrink geometric figures, represent new paradigmatic pedagogical changes teachers must make if they are to fully incorporate the use of the newer technologies (De Vita et al., 2014; Glover et al., 2005). To aid in the understanding that the impact of technology has upon mathematics teaching, Niess et al.

(2009) studied mathematics teachers learning to integrate technology over a four year period and found that teachers progressed through a five-stage developmental process. These stages are:

1. Recognizing (knowledge): Teachers are able to use technology and recognize alignment of technology with mathematics content, yet do not integrate it with the teaching and learning of mathematics.

2. Accepting (persuasion): Teachers form a favorable or unfavorable attitude toward teaching and learning mathematics with an appropriate technology.

3. Adapting (decision): Teachers engage in activities that lead to a choice to adopt or reject teaching and learning mathematics with an appropriate technology.

4. Exploring (implementation): Teachers actively integrate teaching and learning of mathematics with an appropriate technology.

5. Advancing (confirmation): Teachers evaluate the results of the decision to integrate teaching and learning mathematics with an appropriate technology (Neiss et al., 2009, p. 9).

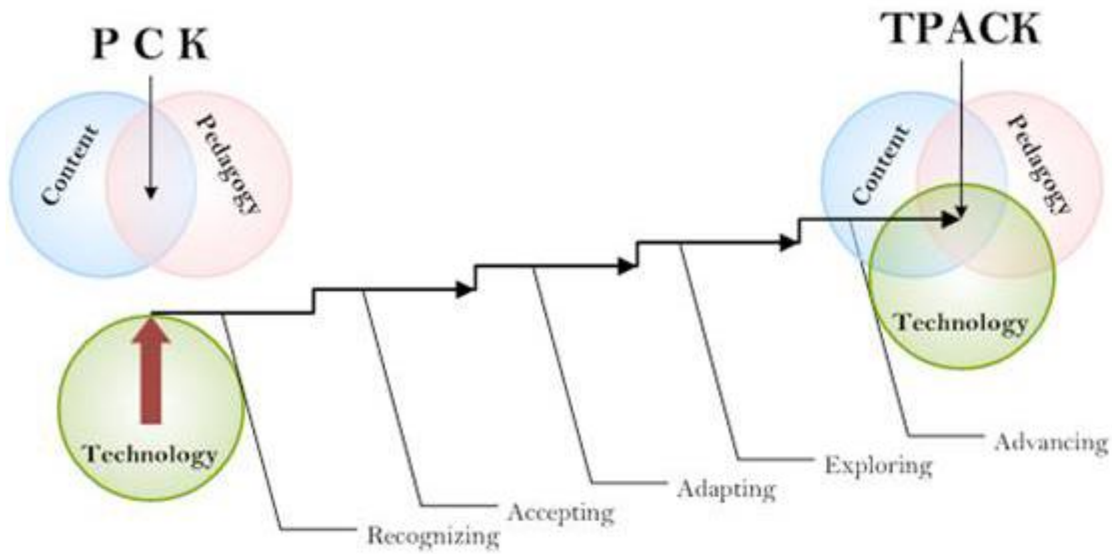

Figure 1.2 Five stages of teacher progression

It is interesting to note that teachers do not go through the five stages in a linear fashion. The progression is iterative in the development of TPACK knowledge. Averis, Glover, and Miller (2005) identified three levels in which teachers are using the IWB: support didactic, interactive, and enhanced interactivity. Support didactic is using only the visual aspects of the IWB and not any of the affordances to support conceptual understanding. Interactivity is using the potential of IWB – the verbal, visual, and aesthetic stimuli to demonstrate concepts and make students think (Miller, Averis, Door, & Glover, 2005). Enhanced interactive is the highest level of IWB use identified by Averis, Glover and Miller (2005). At this level, the teacher is aware of the IWB use in effective teaching and uses the IWB as an integral part of their teaching to encourage conceptual understanding and cognitive development. The ability of the IWB to present content in the verbal, visual, and aesthetic stimuli prompts discussions, explains processes, and develops a hypothesis to facilitate student learning (Miller et al., 2005). Indeed, the inclusion of newer technologies in mathematics classrooms can be an impetus for teachers to change how they teach in order to make the most effective use of IWBs. Therefore, additional research in the areas of instructional practices with IWBs in algebra classrooms is needed (De Vita et al., 2014; Moss et al., 2007). The proposed study responds to this need to investigate teacher use of the IWB.

Significance of the Problem and Research Question

Considering the role mathematics has in influencing technology in contemporary society (Martin, 1997), the findings from this study will be beneficial. Schools, teachers, and parents are pushing students to take more mathematics courses to help prepare students for either a work or college pathway. Students need a strong mathematical background to be successful in today's society (NCTM, 2014), and teachers need to find creative ways to teach mathematics for the purpose of meaningful mathematical learning. The push to use IWBs in classrooms is worldwide, with a majority of research being conducted in the United Kingdom, United States, Canada, and South Africa (Bruce et al., 2011). IWBs are no longer considered a novelty, instead they are a normal part of the mathematics classroom (De Vita et al., 2014) in which mathematics teachers are expected to use them. Yet, questions persist regarding the ways teachers are using the IWB, which undergirds the line of inquiry in the proposed study. Therefore, the research question for this study is:

How does the use of an IWB impact an algebra teachers' implementation of selected mathematics teaching practices?

Context and Sources of Data

The setting for this study was a public high school where teachers were using the IWB in an algebra classroom. I interviewed three teachers to discern their level of IWB use based on Glover et al (2005) level of IWB use. Observations were conducted in the classrooms of teachers using the IWB. The Mathematics Classroom Observation Protocol for Practices, M.C.O.P.[2] (Neiss, 2009) was used to measure the teacher's mathematics teaching practices as defined by the NCTM (2014), *Principles to Action*.

Assumptions

The proposed study makes three assumptions. First, the assumption of IWB use in the algebra classroom is worthwhile both for the teacher and the student (De Vita et al., 2014). I am basing this upon my own experiences as an algebra teacher as well as the research literature, since the IWB helps in the presentation of difficult mathematical content (Miller & Glover, 2007). Next, I assume teachers' levels of use of the IWB will fall into one of these categories: support didactic, interactive, and enhanced interactive (Glover et al., 2005). Finally, I contend students will be receptive to the use of the IWB (De Vita et al., 2014) and, based upon my teaching experience, students are open to the inclusion of technology in the classroom.

Limitations

The results from the proposed study will be limited in terms of its generalizability. The focus of the proposal will be algebra classes that are taught using IWB, and results might not be applicable to other mathematic classes or other content areas. Further, the data of the study will come from public high schools, and results for this group may not be useful for application in other settings, for instance private or charter schools.

Definitions

Mathematics teaching practices. Mathematics teaching is a complex and difficult process. Teachers must possess sufficient content knowledge and have the pedagogical knowledge to effectively impact the student in learning the mathematical content. The NCTM (2014) has identified eight mathematics teaching practices to provide a framework to strengthening mathematics teaching and learning. They are listed below:

1. Establish mathematics goals to focus learning: Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.

2. Implement tasks that promote reasoning and problem solving: Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.

3. Use and connect mathematical representations: Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.

4. Facilitate meaningful mathematical discourse: Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.

5. Pose purposeful questions: Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.

6. Build procedural fluency from conceptual understanding: Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.

7. Support productive struggle in learning mathematics: Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.

8. Elicit and use evidence of student thinking: Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

TPACK. Teaching mathematics with technology is a complex process that requires knowledge from the domains of mathematics, technology, and teaching. (Moersch & Koehler, 2006) TPACK model is the intersection of these three domains:

Pedagogy. Practice of teaching (Shulman, 1986)

Content Knowledge (CK). Facts, concepts, theories and principles that are taught and learned (Mishra & Koehler, 2006)

Pedagogical Knowledge (PK). Teachers' knowledge about process, practice, and methods of teaching and learning (Mishra & Koehler, 2006)

Technological Knowledge (TK). Knowledge about standard technologies, such as books and advanced technologies, such as computers, and internet (Mishra & Koehler, 2006)

Pedagogical Content Knowledge (PCK). The content knowledge pertaining to the teaching process (Shulman, 1986)

Technological Content Knowledge (TCK). Knowledge of how technology and the content are related (Mishra & Koehler, 2006)

Technological Pedagogical Knowledge (TPK). Knowledge of affordances technology can offer to teaching (Mishra & Koehler, 2006)

Technological Pedagogical Content Knowledge (TPCK). Knowledge of affordances technology can offer in the teaching of specific content (Mishra & Koehler, 2006)

Basic algebra class. Group of algebra students are grouped together based upon prior mathematics grades or test scores. The curriculum in these classes are typically taught over longer time periods than traditional algebra classes, typically twice as long (Miller et al., 2005).

Enhanced interactive. The teacher is aware of the affordances of IWB use in teaching and uses the IWB as an integral part of his or her teaching to encourage conceptual understanding and cognitive development. The verbal, visual, and aesthetic stimuli of the IWB is used to prompt discussions, explain processes, and develop hypotheses to facilitate student learning. A wide variety of materials are incorporated in the use of the IWB, such as JavaScript apps, internet resources, and teacher-created content (Miller et al., 2005).

Interactive. The teacher makes some use of the potential of IWB, the verbal, visual, and aesthetic stimuli to demonstrate concepts and encourage students to think deeply (Miller et al., 2005).

Support didactic. Teachers makes use of IWB but mainly for the visual support of the lesson and not concept development (Miller et al., 2005).

Interactive white board (IWB). This is a presentation device that connects to a computer to allow the demonstration of a wide array of content, such as PowerPoint, PDF, Word documents, other software, and JavaScript.

The IWB is placed in classrooms with the expectation teachers will use them (Devita et al., 2014), and there is literature that shows the positive impacts of the IWB (Nejem & Muhanna (2014); Serin (2015). Yet, even with the positive indications of the use of the IWB, questions remain regarding the pedagogical practices. Miller et al (2005) define the three levels of IWB use, from lowest to highest: support didactic, interactive, and enhanced interactive. The NCTM (2014) identified eight effective mathematics practices to provide a framework to strengthening mathematics teaching and learning.

Therefore, it is the aim of this study is to investigate the algebra teachers' use of the IWB and the implementation of selected mathematical practices.

CHAPTER TWO
LITERATURE REVIEW

The literature review is composed of an introduction, review of the literature, and summary. The introduction will provide background information. An Education Source, ERIC, Google Scholar, along with prominent mathematics education research journals such as JRME, JRTE, AMTE, and MTE were searched for literature relating to the research areas for this proposal. The literature search produced articles that are included in the construction of this literature review and are from the following areas: TPACK, IWB, IWB use in the algebra classroom, qualitative and quantitative studies involving the IWB in the algebra classroom, IWB literature reviews, instruments used in IWB studies, effective mathematical teaching practices, and meta-analysis articles relating to IWB.

Conceptual Framework

The existing literature is robust on the positive influence IWB use has upon student engagement in the algebra classroom (De vita, Verschaffel, & Elen, 2014; Holmes, 2009; Swan, Schenker, & Kratcoski 2008). Smith, Higgins, Wall & Miller (2005) connected the use of the IWB in the algebra classroom to an increase in student interactivity and student engagement. Swan et al. (2008), and Moss et al. (2007) found a positive impact of using the IWB upon student achievement by measuring student achievement through achievement tests, pretest/posttest or a series of tests given over time. De Vita et al. (2014) completed a literature review and indicate the majority of studies measure teacher use of IWB through observations, student and teacher surveys, and interviews. In spite of these studies indicating the positive influences the IWB has upon students in the algebra classroom, there remain gaps in the literature. Specifically, how does the use of an IWB impact an algebra teacher's implementation of selected effective mathematics teaching practices?

School districts are investing in technology to aid in teaching and learning in the classroom. Teachers are expected to use the IWB technology and incorporate them into their pedagogical practices. Pertaining to the influence on teacher use of technology, the literature is in its infancy, yet some guidance is offered for best practices in utilizing the technology in individual classrooms. One such model used to investigate the use of technology is the TPACK model.

Historical TPACK

The teaching and learning of mathematics is a complex process with many variables that influence both and is viewed through the lens of Pedagogical Content Knowledge (PCK). PCK is a model which offers to describe the complex process of teaching and learning and is based on Shulman's belief that a teacher's content knowledge and pedagogy are not mutually exclusive, but are interrelated (Shulman, 1986). Content knowledge focuses on the subject the teacher is trying to teach, which consists of the information, facts, and understanding a teacher brings with them from a particular domain, such as mathematics, history, English, and so forth (Ball, Thames, & Phelps, 2008; Shulman, 1986). Pedagogy is understood to be the method the teacher uses to facilitate content acquisition in the learner (Vinner, 2002). Traditionally, prior to 1986, the method of training student teachers was to take educational methods courses separate from the content domain the teacher was specializing. This was the dominate view of the educational field: to keep the content knowledge area and teaching methodology classes separate. Shulman (1986) contends pedagogical and content knowledge are inseparable, but the intersection, and resulting interactions, of these two domains guides teacher actions within the classroom.

The incorporation of technology in the classroom has an impact upon the teaching and learning. The expectation is for teachers to incorporate technology into their classrooms, which presents standardization issues with utilizing the technology for student learning. The inclusion of the technology does afford opportunities (Gibson, 1977) for the presentation of content knowledge and appears to influence the pedagogical practices of teachers. Mishra and Koehler (2006) propose the intersection of Technology, Pedagogy, and Content Knowledge, TPACK, as a model to describe the complex interaction of these components in the teaching and learning. The TPACK model (Appendix A) consists of knowledge from seven areas: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK).

An explanation of these seven areas of knowledge is as follows: Content Knowledge is the content of a particular domain that a teacher is trying to teach (Ball et al., 2008). The content consists of facts, concepts, theories, and principles that are to be learned (Mishra & Koehler, 2006). Teachers need to have the knowledge of the content they are teaching in order to be prepared for student learning However, the methods used to teach the content is equally important and is referred to as Pedagogical Knowledge (Shulman, 1986). Pedagogical Knowledge is the manner in which a teacher conveys their content knowledge to the student. Mishra and Koehler (2006) define pedagogical knowledge as a teacher's knowledge about process, practice, and methods of teaching and learning. The teacher conveys the content to the student to ensure learning occurs, which is influenced by the methods the teacher utilizes. Technology is one method the teacher can utilize to deliver the content. Technological knowledge is the knowledge of thinking about technology for use in everyday life and work. This includes information technology and having the ability to discern appropriate uses of the technology for learning. The teacher needs to constantly evaluate and adapt to the changes of the information technology that influence their technological knowledge (Mishra & Koehler, 2006).

Content, Pedagogical, and Technological Knowledge are important in their influence upon student learning but do not act independently of each other; rather, they interact, influence, and have a symbiotic relationship between them. The intersection of Content Knowledge and Pedagogical Knowledge, Pedagogical Content Knowledge is what Cochran (1991) describes as a unique type of knowledge in which teachers relate their pedagogical knowledge to their particular subject knowledge for the purpose of teaching. Shulman (1986) asserts this area of knowledge necessitates teachers to transform their teaching styles to find multiple ways to reach the student for learning the content. One such way to reach students is the inclusion of technology in teaching content, or Technological Content Knowledge.

Technological Content Knowledge is the teacher's understanding of the positive or negative impact technology can have on the content of a particular domain (Mishra & Koehler, 2006). This requires teachers to have a deep understanding of the content and the appropriateness of the affordances the technology may or may not offer (Gibson, 1977). The influence of the technology upon the pedagogical practices is another area of knowledge that influences teaching and learning and is termed Technological Pedagogical Knowledge.

Technological Pedagogical Knowledge is the intersection of Technological Knowledge and Pedagogical Knowledge. Mishra and Koehler (2006) define Technological Pedagogical Knowledge as an understanding teachers have in the relationship between use of particular technologies and the associated impact upon their teaching and student learning. The intersection of Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Knowledge is referred to as Technological Pedagogical Content Knowledge, or TPACK.

TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face, knowledge of student' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones (Koehler & Mishra, 2009, p. 66).

Historical IWB

The IWB is a device that connects to a computer and projector to enable the delivery of content. The IWB is known by the trade names of SMART Board or Promethean Board and was initially developed for use within the business community to facilitate the delivery on content during meetings that were conducted at different locations. The use of the IWB moved into the educational community for two reasons: a tool for enhancing teaching and a tool to support learning (H. J. Smith et al., 2005). The IWB can enhance teaching by allowing the teacher to present a lesson within multiple screens to accommodate a classroom of different levels of students. This allows the teacher to more easily organize and access content that are not easily available under traditional teaching methods. The IWB is a versatile teaching tool (Austin, 2003; Jamerson, 2002) that is beneficial to different student age groups and a variety of settings (Lee & Boyle, 2003).

Effective Use of IWB

The idea of using IWB in classrooms is for the purpose of creating an interactive classroom environment to support student learning, yet just having the technology in the classroom does not necessarily mean it will be used in an appropriate manner. The teacher needs to have the understanding of the potential it can offer to aid in their pedagogy, yet it is sometimes used as a glorified black board (De Villiers, 2006; Greiffenhagen, 2000, 2002, 2004) and in creating a teacher-centered learning environment. Glover, Miller, Averis, and Door (2007) define using the IWB as a glorified blackboard or in a teacher-centered learning environment as support didactic, which is not an effective use of the IWB. A higher level of IWB use as defined by Glover et al. (2007) is interactive. Interactive use entails the teacher making some use of the potential of IWB – the verbal, visual and aesthetic stimuli – to demonstrate concepts and make students think deeper (Miller et al., 2005). Examples include:

- Coloring and highlighting important content using the hide/reveal and drag and drop function (Türel & Demirli, 2010)
- Flipping back and forth between content (Levy, 2002; H. J. Smith et al., 2005)
- Use pictures for class discussion, peer-teaching, collaborative problem solving
- Observing different media-visual learners (Bell, 2002)
- Touch and manipulate content (Bell, 2002)
- Zoom in on content; good for visually impaired (L. Smith, 2008)
- Capturing screenshots (Miller et al., 2004)
- Use of spotlight to reveal hidden part of screen (Beauchamp & Parkinson, 2005).

This is not an exhaustive list, but it illustrates some effective uses of IWB. When the teacher is aware of the affordances the IWB has to offer to the pedagogical practices, and uses them as an integral part of their teaching for conceptual understanding of mathematical content to spur cognitive development, this is the highest level of IWB use and is termed by Glover et al. (2007) as enhanced interactive. Beauchamp and Kennewell (2013) propose the following levels of IWB use: basic, apprentice, initiate, advanced, and synergistic. The basic is when IWB is used only as a blackboard substitute. Apprentice level is characterized by the teacher using a wider range of computer skills in a teaching context (Beauchamp, 2004), such as using clip art to decorate a presentation or using a PowerPoint. Once teachers have achieved some technical competency at the apprentice level, and realize the potential of the IWB to change their teaching practice, they have moved to the initiate user level. Indicators of this level of use might be the inclusion of sound and a wider range of graphics, which are not just for decoration but serve a learning purpose (Beauchamp, 2004). The advanced user is the next level identified by Beauchamp (2004). At this level, teachers realize the possibilities in a IWB program and want to play around and explore the possible ways they can be used to impact their teaching and learning (Beauchamp, 2004). Examples of this advanced user are the use of hyperlinks in the IWB, going back and forth between different programs, and the inclusion of other input devices, such as the slate , which enables a teacher or student to transfer handwriting to the IWB; the use of slates is helpful in solving math problems because the student is able to work out problems to spur class discussions. The synergistic user employs the IWB as the functioning hub for classroom activity. This occurs when the teacher realizes the IWB can facilitate a synergy of learning in which students and teachers combine technical skills with teachers' pedagogic vision for a new learning praxis (Beauchamp, 2004). It is the intersection of the pedagogical practices with the technology along with the content knowledge that is described by Mishra and Koehler as TPACK.

The intersection of Technological Pedagogical Knowledge, Technological Content Knowledge, and Pedagogical Content Knowledge has been termed by Mishra and Koehler (2006) as Technological Pedagogical Content Knowledge (TPACK) (Appendix A). The use of TPACK as a theoretical framework to investigate the use of IWB in math classrooms is not new. Archambault and Barnett (2010) utilized the TPACK framework to investigate IWB use by administering a 24-item survey to measure teachers' TPACK scores, and Niess et al. (2009) developed a model for TPACK that measured teachers' progression through five stages, while integrating a particular technology into their teaching mathematics. Glover et al. (2005) identified three levels of teacher use of the IWB: support didactic, interactive, and enhanced interactive. The support didactic level, or lowest level of IWB use is characterized by the teacher using the board only as a presentation device. The interactive level of IWB use includes the teacher's use of the dynamic capabilities of the IWB, and the enhanced level is teacher awareness of the affordances the board has to offer in conceptual understanding. These three levels of IWB use are identified by the literature as all-encompassing. Therefore, this proposal will utilize Glover's levels of IWB use to capture data regarding teachers' levels of IWB use.

Therefore, based on prior literature, the use of the TPACK model is an appropriate conceptual framework to investigate the use of the IWB in teaching algebra to provide an understanding of this complex process. A case study research method will be utilized in this proposal to obtain the data for analysis of teacher use of the IWB.

IWB and Student Achievement

This section of the literature review will address the area of IWB use and student achievement. The layout in this section of the literature review will be as follows: First, an introduction of literature addressing the IWB's use and history in conjunction with student achievement. Next, literature that indicates the positive impact upon student achievement will be presented. Third, literature indicating negative or no impact upon student achievement, followed by a summary. The research literature in the area of IWB and student achievement are mostly qualitative case studies and literature reviews, with few quantitative studies.

School districts are driven by the appearance of keeping up with the latest technology and the expectation to utilize the technology for the purpose of increasing student achievement within their classrooms. The IWB is one such device that is used in the classroom for this purpose (Somekh et al., 2007). In the readings of the literature pertaining to IWB use, several themes emerge relating to the impact upon student achievement. The themes are: motivation, engagement, and interaction (H. J. Smith et al., 2005). The literature on the use of IWB in schools is broad and widespread, yet there are questions that remain about the use of the IWB in the algebra classroom and the relationship to student achievement (S. J. Higgins & Association, 2003). The literature indicates a relationship between IWB use and engagement (Beauchamp, 2004; Beeland, 2002), student motivation (Torff & Tirotta, 2010), and interactivity (Glover et al., 2003). Teachers are expected to use technology in teaching, and the IWB is a tool that is being used by schools around the world (H. J. Smith et al., 2005) for the purpose of influencing student achievement. However, the influence the IWB has upon student achievement is not necessarily a direct one. Beeland (2002) proposes that the effective use of the IWB helps to engage students in the learning in order to motivate, which has an impact upon student achievement. Beauchamp (2004) in a qualitative study of primary school teachers found that using the IWB can help to get students attention and keep students engaged in the learning of content. Schoenfeld (1992) ascribes that learners need to be engaged with the mathematical thinking, and the IWB is a tool that can facilitate the pedagogical interactivity (Averis et al., 2005) for meaningful mathematical learning. The affordances of the IWB can make the classroom more conducive for interactivity and create opportunities for the sharing of knowledge (De Vita et al., 2014; F. Smith, Hardman, & Higgins, 2006). Even with literature on the positive impact upon student achievement, engagement, motivation, and interactivity, there is also literature that disputes the impact upon student achievement and even goes as far as to show a negative impact.

Moss et al. (2007), in a mixed method research design study consisting of case studies, surveying teacher IWB use, and the analysis of student performance data, indicated students were initially receptive to the use of the IWB and increased student motivation, but there was no impact on student achievement. Similarly, Harrison et al. (2002), in a study involving 30 primary and 25 secondary schools in which students were taught with technology (ICT, information and communications technology), found there were no statistically significant differences in students taught with the technology than those students taught without. There are even studies that show a negative influence upon student achievement with the use of the IWB. Zevenbergen and Lerman (2007, 2008) observed 15 classrooms over a period of three years in Australia to observe ways in which the IWB is used to support mathematical learning compared to those not using the IWB. For analysis of the data, the authors used the categories of quality of learning: intellectual quality (deep understanding), relevance (knowledge integration), supportive school environment (social support), and recognition of difference (inclusivity) to measure quality of learning. The analysis of the data concluded, classes using the IWB had a reduction in the quality of mathematical learning (Zevenbergen & Lerman, 2007, 2008). With studies that indicate either positive or negative impacts upon student achievement, there are studies that indicate a mixture of outcomes with IWB use. Tataroğlu and Erduran (2010) in a quasi-experimental design investigating the attitudes of students taught with IWB concluded with outcomes of mixed results. Findings of increased motivation were attributed to the IWB being used in the classroom, but the students felt the increased pace created by the fluidity of the IWB used in the lesson caused a negative situation for the them. A few students even articulated the lesson was not going in a logical order, and the students had trouble seeing the board due to the teacher blocking their view of it. Wall et al. (2005), in a qualitative study that focused on student perspectives of IWB use and the resulting teaching and learning process, also had mixed results regarding IWB use and student achievement. Specifically, Wall found that the students taught using the IWB perceived the positive and negative influence the IWB presents in the classroom, and the students were aware of the positive and negative impact it can have on teaching and learning (Wall et al., 2005).

The use of the IWB in the classroom is driven by school districts wanting to be viewed as on the technological edge for the purpose of having a positive influence upon student achievement. The literature is positive about the capabilities and affordances of IWB use in the algebra classroom. Devita (2014) states the IWB is particularly useful in teaching mathematics, and Glover (2005) affirms the use of the IWB will transform the teaching of mathematics with the potential to support further student performance. Somekh et al. (2007), in a large scale qualitative study concluded students in primary grades, taught with the IWB for longer lengths of times, which showed the greatest gains in student achievement. Swan et al. (2008), in a quasi-experimental study conducted in Ohio, which consisted of elementary, junior high, and an alternative school grades three through eight, indicated an increase in student achievement on the Ohio Achievement Test for those students taught mathematics with the IWB. While there is plenty of literature to support the use of the IWB in the mathematics classroom and its ties to student achievement, there is some literature that counters that assertion.

Moss et al. (2007) conducted a large-scale, mixed-methods study in London secondary public schools in subject areas of Science, English, and Mathematics. The statistical analysis of data from the study showed no impact upon student achievement. In a meta-analysis by De Vita (2014) on the use of the IWB, only four studies were identified that dealt with students' cognitive outcomes, of which only two showed small statistically significant difference in student achievement. The literature on IWB use and student achievement is diverse in studies that show a positive impact; some indicate a negative impact and some show no impact whatsoever. Nonetheless, themes of student engagement, interactivity, and motivation are apparent in most of the reviewed studies, and these themes do influence increased student achievement.

Effective mathematical teaching practices

Algebra is an important mathematics course for students and serves as a gateway course for students being successful at higher level mathematics courses in high school and later in college (McCoy, 2005; Moses & Cobb Jr, 2001). Typically, students take an algebra course during their middle school years; as it is common for students to lose interest in algebra during the time of adolescence, which presents a negative impact on student performance in algebra (Fredricks & Eccles, 2002; Frenzel, Goetz, Pekrun, & Watt, 2010; McCoy, 2005). This is further compounded with high failure rates in algebra for minority students and students from low socioeconomic statuses (Moses & Cobb Jr, 2001). This prompts school districts to implement a strategy to focus on the teaching and learning of algebra for students to be successful. Schools have responded by splitting the standard algebra content taught normally over a one-year period to two years, and the scheduling of double block algebra classes to help students be successful in the learning of algebra. There are those that believe in omitting algebra from the curriculum all together (Walkington & Wasserman, 2013). However, there is currently little support for removing algebra from the curriculum; instead, the NCTM (2014), in *Principles to Action*, has identified eight effective mathematical practices for teachers to employ in their classrooms:

1. Establish mathematics goals to focus learning: Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.

2. Implement tasks that promote reasoning and problem solving: Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allows multiple entry points and varied solution strategies.

3. Use and connect mathematical representations: Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematical concepts and procedures and as tools for problem solving.

4. Facilitate meaningful mathematical discourse: Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.

5. Pose purposeful questions: Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making skills about important mathematical ideas and relationships.

6. Build procedural fluency from conceptual understanding: Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding

so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.

7. Support productive struggle in learning mathematics: Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports them to engage in productive struggles as they grapple with mathematical ideas and relationships.

8. Elicit and use evidence of student thinking: Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning (NCTM, 2014).

For the purposes of this study, not all eight effective mathematical teaching practices (MTPs) will be utilized. The rationale for including only five of the effective MTPs comes from the pilot study when only these five of the eight practices were observed: Establish mathematics goals to focus learning, Implement tasks that promote reasoning and problem solving, Use and connect mathematical representations, Pose purposeful questions, Support productive struggle in learning mathematics. These will be referred to as selective mathematics teaching practices henceforth. To further explain, the rationale for using only these five mathematics teaching practices was based upon the coding scheme developed during the pilot study. Below is an explanation of why I coded these five selective mathematics teaching practices:

1. Establish mathematics goals to focus learning: Coded as Structure (S) as I observed teacher using IWB to structure learning.

2. Implement tasks that promote reasoning and problem solving: Coded as Review/Prior Learning (R/PL) as I observed reviewing prior learned content or heard teaching referencing prior learned content while using the IWB.
3. Use and Connect Mathematical Representation: Coded as verbal visual (V/V) as I observed teacher using IWB visual capabilities and making an associated verbal reference to the IWB.
4. Pose purposeful questions: Coded as Questioning (Q) as I observed/heard teacher using IWB and using questions.
5. Support productive struggle in learning mathematics: Coded as Productive Struggle (PS) as I observed teacher using IWB and observed productive struggle in students.

The remaining three MTPs (Mathematics Teaching Practices: Facilitating meaningful mathematical discourse Build procedural fluency, and Elicit and use evidence of student thinking) were not observed and, therefore, not coded during the pilot study. Hence, the focus of the study is constrained to the five MTPs that were observed and will be addressed in the findings.

In closing, the use of the IWB in the teaching and learning of algebra may make for more meaningful algebra learning environments to support a deeper understanding of the content. The ability of the IWB to engage students (Glover et al., 2003), motivate them (De Vita et al., 2014), and aid teachers in the presentation of material through the enhanced visual affordances directly impacts the learning of algebra (Walkington & Wasserman, 2013). The use of pedagogical practices in connecting current material to prior learning is tied to the use of the IWB, as it presents multiple representations of algebra content, which may support conceptual understanding and prepare students for subsequent higher mathematics courses.

Effective mathematical teaching practices that contribute to the learning of algebra have been discussed above, along with the use of the IWB in the algebra classroom. Teachers need to have strong content and pedagogical knowledge in order to make the learning of algebra meaningful for conceptual understanding ((Mishra & Koehler, 2006). The affordances of the IWB, along with the teacher's strong content and pedagogical knowledge is the common ground of the TPACK model to support the meaningful learning of algebra. Glover et al. (2005) has identified levels of use of the IWB based upon studies of teachers' practices and surveys of the literature. Support didactic is the lowest level of use when the teacher is only using the IWB for the visual support of the lesson and not for conceptual understanding (Miller et al., 2005). In essence, the teacher is only using the IWB as a so-called glorified white board. The next level of use above support didactic is the interactive. This level is described by Glover et al. (2005) as the teacher making some use of the potential of IWB, specifically, the verbal, visual, and aesthetic stimuli, to demonstrate concepts to make students think critically. The highest level of use of the IWB is the enhanced interactive. It is at this level of use that the teacher is aware of the affordances the IWB has to offer to the pedagogical practices and uses them as an integral part of their teaching for conceptual understanding of mathematical content to spur cognitive development (Glover et al., 2005). The teacher's use of the verbal, visual, and aesthetic stimuli of the IWB – for the purpose to prompt interactive discussions, explain processes, and develop hypotheses – makes this level of use superior to the interactive level. In addition to creating an engaging and interactive environment, the teacher incorporates a wide variety of materials for use with the IWB, such as JavaScript apps, internet resources, and teacher-created content (Miller et al., 2005).

The teaching and learning of algebra are intertwined and have a symbiotic relationship. Some literature has gone as far as to say the best way to learn algebra is conceptual understanding (NCTM, 2014) in conjunction with teachers possessing pedagogical skills to unpack the mathematical knowledge to make the content more understandable to the students they teach (Ball & Bass, 2000). The use of multiple representations (Fuson, Kalchman, & Bransford, 2005; Lesh, Post, & Behr, 1987), meaning making of algebra learning (NCTM, 2014), connecting new knowledge to old knowledge (Goldstone & Son, 2005), and creating social learning opportunities (Glover et al., 2005; NCTM, 2014) are methods the IWB can support for conceptual understanding. Teachers must also develop the ability to recognize the affordances the IWB has to offer to apply with their content knowledge for the successful use of the IWB for meaningful algebra learning.

The purpose of this literature review was to investigate the areas of TPACK, IWB, student achievement, and teaching and learning of algebra. The TPACK model is used as the conceptual framework to investigate the phenomena of using the IWB in the teaching and learning of algebra. A brief historical overview of the formation of the TPACK model and the genesis of the IWB provide a background for its evolution and the currently utilized methods involved with the IWB in the educational community, particularly the algebra classroom. The review of the literature indicates several themes that emerged in regards to the IWB. They are the use of the IWB supports teaching and enhances learning in the algebra classroom. Similarly, the themes of motivation, engagement, and interactivity were identified in the literature review in the area of student achievement and IWB use in the classroom. The literature investigation in the area of algebra indicated there is a symbiotic relation between the practice of teaching algebra and student learning of algebra.

The major findings of the literature search indicate the following: First, the use of the IWB has an impact upon engagement, motivation, and interactivity (De Vita et al., 2014; Holmes, 2009; H. J. Smith et al., 2005; Swan et al., 2008). Second, there are studies that indicate IWB use has a positive impact upon student achievement (Nejem & Muhanna, 2014; Serin, 2015; Somekh et al., 2007), and those that indicate no impact upon student achievement (S. Higgins et al., 2007). Third, the use of the IWB to teach algebra through the display of multiple algebraic representations (De Vita et al., 2014; Fuson et al., 2005; Glover et al., 2005; Lesh et al., 1987; Miller et al., 2005) allows for the conceptual understanding and meaning making (NCTM, 2014) of the mathematical content. Fourth, the use of IWB may create a less teacher-centered and more student-centered environment to allow for the social opportunities for the sharing of knowledge (De Vita et al., 2014; NCTM, 2014; F. Smith et al., 2006). Finally, the identification of a teacher's level of IWB use as support didactic, interactive, and enhance interactive (Miller et al., 2005) will serve as an analysis tool for this study.

CHAPTER THREE

METHODS

The purpose of this chapter is to describe the research design and methodology to investigate the following research question: How does the use of an IWB impact an algebra's teacher's implementation of selected mathematics teaching practices? This chapter is comprised of the following sections: Introduction, participants, instrumentation, procedures, data analysis, limitations, trustworthiness, and summary. There are three methods to investigate research in the field of mathematics education: quantitative, qualitative, and mixed methods (Creswell, 2013; Yin, 2013). The strengths of quantitative research include reliable and consistent data, data that are simple to analyze, and findings can be generalized from a sample to a larger population. Even with this strength, quantitative research does not fully capture all of the data when utilized to investigate certain types of phenomena. Qualitative methods are useful to investigate phenomena that quantitative methods cannot fully describe (Creswell, 2013). The researcher in a qualitative study serves as an instrument to observe the phenomenon, make conjectures, and collect and analyze data. Some feel the researcher introduces bias in qualitative research and that the results from these studies are not generalizable to a larger group from which the sample is taken. However, the strength of qualitative research is the capacity to provide rich descriptions of phenomena (Yin, 2013).

This proposal will use a case study research design to investigate the phenomena of teacher use of IWB in the algebra classroom. This study examined the impact upon the teacher's implementation of selected effective mathematical teaching practices.

Conceptual Framework

The TPACK model has been used to investigate teacher use of the IWB (Glover et al., 2007; Hofer & Grandgenett, 2012;) and will be used as the conceptual framework for this proposal and analysis of data. TPACK model is composed of Technological Knowledge, Pedagogical Knowledge, Content Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006). Glover et al. (2005) utilized the TPACK as a conceptual framework in studies and identified three levels of teacher use of IWB: Support Didactic, Interactive, and Enhanced Interactive. These levels were utilized in this study in the analysis of data.

The purpose of this study is to answer the following research question: How does the use of an IWB impact an algebra teacher's implementation of selected mathematics teaching practices? The population for this study consisted of three secondary high school algebra teachers in public high schools that use the IWB. After a site was selected for the study, potential participants were interviewed to identify their level of IWB use. Analysis of teacher interviews aided in the identification of participants that teach algebra and use the IWB at different levels. Teachers of content beside algebra or teachers with no use of the IWB were excluded from this study. Further analysis of the interviews to discern the algebra teacher's level of IWB use helped to identify the three participants for this study.

Instrumentation

The purpose of this section is to describe the instruments used in this study to obtain data to answer the research question. Two instruments were used: (1) a teacher interview and (2) the Mathematics Classroom Observation Protocol for Practices ($MCOP^2$).

Teacher interview. The first instrument used for this study was the teacher interview, which was used to obtain the level of IWB use. The teacher interview consisted of questions developed from Glovers et al. (2005) levels of IWB use, which are support didactic, interactive, and enhanced interactive (Appendix B). For example, the teacher was asked if he or she had verbal stimuli in the lesson they created with the IWB that challenged students to think. If the teacher answered yes, they were coded at the interactive level of IWB use. The teacher was also asked if they had visual stimuli in the lesson they created with the IWB that challenged students to think. If the teacher answered yes, they were coded at the interactive level of use. These two examples were developed from Glover et al (2005) level of IWB use. The teacher interview was used to discern each teacher's level of IWB use based upon their answers to each question. Appendix B gives the full details on categorized responses. The interview also contained demographic questions such as, how long have you been teaching, and how long have you used the IWB?

Mathematics Classroom Observation Protocol for Practices ($MCOP^2$). This study used the Mathematics Classroom Observation Protocol for Practices ($MCOP^2$) as an instrument to obtain the degree of alignment of the mathematics classroom with the mathematics teaching practice as identified by the NCTM, *Principles to Action,*

(Appendix C) (Gleason et al., 2015). The MCOP^2, developed by Dr. Jim Gleason from the University of Alabama, measures two factors: teacher facilitation (Cronbach alpha of 0.850) and student engagement (Cronbach alpha of 0.897) (Appendix C). The MCOP^2 has been validated (Gleason et al., 2017) and can be utilized to analyze either a live or videotaped settings of complete lessons with practicing teachers (Gleason et al., 2015). Teacher facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse" and is scored from 0 to 27. A higher number means more teacher facilitation, while a lower number represents lower teacher facilitation. Student engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement, while a lower number indicates lower student engagement.

Data Collection Procedures

This study utilized a case study research design, and IRB approval was obtained for the study (Appendix F). Permission to conduct this study at a public high school was granted, and I met with the principal to discuss the study and identify participants. The table below outlines the procedure used for data collection.

Table 3.1
Data Collection Procedures

Phase 1. Interviewed teachers to identify their level of IWB use, See (Appendix B)
Phase 2. Videotaped teachers using IWB, and classroom setting. Analyzed videos level of use (Miller, Glover, 2005), and MCOP^2 (Gleason et al., 2015).

Potential participants were emailed to inform them about the study and provided consent forms to participate in the study. Once the signed forms were returned to the researcher, teachers were contacted to arrange an interview. Interviews were analyzed to identify potential candidates for the observation portion of the study. More detail about this analysis will be given in the Data Analysis section below. This researcher met with the participants and informed them about the observations (three one-hour observations for each teacher), which were video recorded. Two videos cameras were utilized during the study, along with a microphone attached to the teacher's lapel to capture the teacher's audio. One video camera was focused on the IWB exclusively, and the other video camera focused on the whole classroom.

Qualitative Data Collection

The qualitative data collected was obtained from the participants being interviewed, videoed using the IWB, along with a whole classroom video recording of the setting. Purposeful sampling was utilized in this study. Purposeful sampling is characteristic of qualitative inquiry for "informational, not statistical, considerations…Its purpose is to maximize information" (Lincoln & Guba, 1985, p.202). Purposeful sampling allowed the focus on characteristics of teachers to answer the research question.

Data Analysis

Teacher interviews and videoed observations were analyzed to determine the teacher's level of IWB use, based upon Glover's et al. (2005) levels of IWB use: support didactic, interactive, and enhanced interactive. Data from the whole class video and IWB video were analyzed with the MCOP^2 to determine the selected mathematical teaching practice identified in *Principles to Action*. Specifically, these selected five mathematics teaching practices were used:

1. Establish mathematics goals to focus learning: Coded as Structure (S) when teacher observed using IWB to structure learning.
2. Implement tasks that promote reasoning and problem solving: Coded as Review/Prior Learning (R/PL) when observed reviewing prior learned content or heard teaching referencing prior learned content while using the IWB.
3. Use and Connect Mathematical Representation: Coded as Verbal Visual (V/V) when observed teacher using IWB visual capabilities and making an associated verbal reference to the IWB.
4. Pose purposeful questions: Coded as Questioning (Q) when observed/hear teacher using IWB and using questions.
5. Support productive struggle in learning mathematics: Coded as Productive Struggle (PS) when observed teacher using IWB and observed productive struggle in students.

As explained in Chapter 2 based on the pilot Study results, mathematics teaching practices not used for coding in this study are beyond the focus of this study. MCOP^2 was used to capture the selected mathematical teaching practices, and Excel was utilized to organize and analyze the data from the interviews and videos (Appendix D). NVivo was used for the qualitative data analysis. All IWB videos for each teacher was imported into NVivo and coded for the IWB level of use and selected mathematical practices. Each IWB video was transcribed, imported into NVivo, and synced with the video. Content analysis (Denzin & Lincoln, 2017; Yin, 2015) was the procedure this study utilized to analyze the videos. Each data source and a description of its analysis is below.

Teacher Interview

For each teacher, the interview was recorded and transcribed for review. The complete interview was read through one time to gain an overall impression of the interview. After the initial reading, a second reading of the interview was conducted, and notations were made at interesting comments; a running research log was created as possible overarching codes or themes emerged from reading the interview transcript. During the second reading of the interview, the demographic data were placed into a table format. For instance, if a teacher said he or she had eight years of teaching experience, and became certified by an alternative method, the data were placed into a table for each teacher (Appendix D). Teachers were asked questions to expand on answers that were of interest for this study. For instance, one teacher mentioned she used her IWB in an alternative way by using a ball and throwing it at the IWB screen to facilitate a lesson at the enhanced interactive level. This was coded at the enhanced interactive level per Glover et al's (2005) definition. During this particular interview, the data were highlighted and coded at the enhanced interactive level.

Video Data

For this study, each teacher had a camera pointed at them using the IWB and another camera positioned to view the whole classroom setting. The teacher wore a lapel microphone, and an external boom microphone was on the camera focusing on the whole classroom-setting. Data from these two videos were analyzed as follows. The IWB video was viewed one time to get an overview of the lesson. A second viewing of the IWB video helped identify the IWB functions used and the teacher level of use of the IWB. For example, if a teacher was observed using the erase feature of the IWB, a frequency tally was marked. Frequencies and durations were also noted for the level of IWB use, for support didactic, interactive, and enhanced interactive and placed in a table. The IWB video was viewed a third time, making note of the auditory portion of the lesson, and code for selected MTP. For example, during the auditory portion, questioning, and verbal visual were the selected mathematical teaching practices that were noted as the most occurring during the study, tended to occur in a sequence, but instances occurred when they simultaneously occurred. Frequencies and durations were noted. Purposeful transcription was utilized for instances of interest for this study. For example, the whole class video was viewed one time to get an overview of the lesson. The whole class video was viewed again, and the $MCOP^2$ instrument was used to measure teacher facilitation and student engagement. All data were entered into Excel for descriptive statistics. Data from the interviews and IWB videos were analyzed to determine the level of IWB use, and whole class videos analyzed with the $MCOP^2$ were compared for triangulation. Glover et al.'s (2005) levels of IWB use was the protocol used to analyze teachers' levels of IWB use. For example, if a teacher used the cut and paste function of the IWB, then it was coded as the interactive level of use, based upon Glover et al. (2005) IWB level of use.

External Reviewer

The process for reviewing the data with the external reviewer was as follows: the external reviewer was provided a copy of each IWB Video and the video capturing the whole class setting. The reviewer was provided a copy of Glovers et al.'s (2005) levels of IWB use and a copy of the $MCOP^2$ instrument. This researcher reviewed these documents with the external reviewer, answering any questions. The external reviewer was directed to thoroughly view the IWB Video one time for an overview of the lesson, followed by a second viewing to identify the functions of the IWB used and the teacher level of use of the IWB. The IWB Video was viewed a third time, focusing on the audio portion. Frequency counts were made for each IWB function used, IWB level of use, duration of IWB level of use, and a frequency count and duration of selected mathematical practices. The data from the IWB Video were placed in a table for each video. The Whole Class Video was viewed one time through by the reviewer to gain an overview of the lesson, followed by a second viewing to score the teacher on the $MCOP^2$ for teacher facilitation and student engagement. Data from this video were recorded in a table for each teacher Whole Class Video. Once all videos were coded, the reviewer and researcher met to review any differing analyses and make adjustments. The only changes to data analyses were traced back to keying errors for data values in the tables.

Pilot Study

A pilot study was conducted and followed the above procedures. This allowed the researcher the opportunity to address problematic issues and finalize methods for coding the data. The pilot study was conducted in the fall of 2017. A teacher was identified by collaborating with the principal and the department head to identify someone who taught algebra and used the IWB. The algebra teacher was interviewed and videoed using the IWB, along with a whole classroom video. The pilot study allowed this researcher to identify problems and make adjustments before the study was conducted. Based upon the pilot study, the table below is the detailed plan of coding and data analysis the researcher used in conducting this study.

Table 3.2
How Study Was Conducted, Coded and Data Analysis

Study Procedures	***Coding and analysis***
1. Interview teachers	Purposeful transcribe interviews and code them with NVivo.
2. Video three teachers three times teaching a lesson	One camera on IWB Other camera on classroom
3. View IWB video 1st time	Makes notes, get overview of video
4. View IWB video 2nd time	Code video based on levels of IWB use: support didactic, interactive, enhanced interactive
5. View IWB video 3rd time	Purposeful transcription of video
6. Code Purposeful transcription of video	Use these codes (nodes in NVivo): Q: questioning S: Structure R/PL: Review/Prior Learning V.V.: verbal/visual-teacher says something that is associated with a visual action performed on the IWB P.S.: productive struggle-teacher displays opportunity to allow students to struggle while learning.
7. View whole classroom video	Use MCOP^2 to score teacher.
8. Use NVivo for coding	Code IWB video (thematic and by case) Code transcript Code interview
9. Analyze data	Look at frequency and duration of IWB levels of use by nodes (support didactic, interactive, enhanced interactive), selected MTP and cases (teacher)

Further Video Data Analysis Explanation

In this section, data analysis is further explained by including examples of tables that will appear in their full form in Chapter 4: Findings. The purpose of this section is to offer an in-depth explanation of data analysis and the reasoning behind the values that appear in the table. In Chapter 4: Findings, each participant will have tables to organize the data. The first table in each section captures the organization of the data by teacher. The second table in each section contains data obtained during the teacher interview. The third table in each section contains IWB levels of use and selected MTP. The fourth table in each section contains a matrix query for IWB level of use and selected MTP. The last table in each section contains exemplars of IWB level of use and selected MTP.

Below are values from each participant section, using Table 3.3 and Table 3.4.

Table 3.3
Teacher A IWB level of use and selected MTP for Video 1

	IWB level of use			*Selected MTP*				
	SD*	**I**	**EI**	**Q**	**VV**	**S**	**R/PL**	**PS**
Frequency	7	16	15	50	65	15	0	17
% duration of	2.19	29.74	68.07	6.67	24.64	10.00	0.00	24.86

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

The frequencies of the IWB level of use contain values of 7 for SD, 16 for I, and 15 for EI. These numbers were obtained by counting the occurrences the teacher used the IWB at the IWB level of use. For example, Teacher A used the IWB to display notes for students to read, and this instance was counted as an occurrence of SD. Teacher A was observed using the highlight feature on the IWB, and this instance was counted as an occurrence of I. Teacher A was observed using the IWB by having students throw a ball at the IWB, followed by a sound when the ball struck the IWB. Then, a factoring problem was displayed on the IWB for the class to solve. This instance was counted as EI. Each occurrence for Teacher A for the IWB level of use was counted and placed in the appropriate column in Table A.1.1. Similarly, the frequencies of the selected MTP of Questioning (Q), Verbal Visual (VV), Structure (S), Review/Prior Learning (R/PL), and Productive Struggle (PS) contain values of 50, 65, 15, 0, and 17 respectively. These numbers were obtained by counting the occurrences of selected MTP for teacher A. An example for the selected MTP of Q by Teacher A was when the teacher wrote an equation on the IWB and asked the class if it was in standard form. This instance was counted as an occurrence of selected MTP of Q. An example for the MTP of VV by Teacher A was observed when the teacher was working out a problem dealing with the product property of exponents. The teacher discussed with the class how to work out the problem and referenced the IWB. This action was noted as an occurrence of VV. An example for the selected MTP of S by Teacher A was observed when the teacher multiplied two binomials and used the F.O.I.L. method to facilitate structure for the students. This occurrence was counted as S. There was not an example of R/PL for Teacher A and, hence, no occurrences were counted for R/PL. An example of PS by Teacher A was observed when the teacher put a problem on the IWB dealing with the power property of exponents. The teacher worked through the problem in incremental steps but paused to ask for student input on the next steps. The teacher would allow sufficient time for students to try to complete the step and would offer help as needed to individual students. This occurrence was counted for PS. In addition, the % duration for the IWB level of use and selected MTP for Teacher A were observed. The times Teacher A used selected MTP of Q, VV, S, R/PL, and PS were noted. The % duration for the IWB level of use for Teacher A is 2.19%, 29.74%, and 68.07% for SD, I, and EI, respectively. During Video 1 for Teacher A, the length of the whole video as 44 minutes 52 seconds (hereafter, referred to using the notation 44:52). The teacher was observed using the IWB at the SD level for 13.24, and the % duration was calculated by dividing 13.24/44.52=.2974 or 29.74%. The same process was used to calculate the % duration for I and EI for Teacher A Video 1. The % duration for Teacher A for the selected MTP was observed and are 6.67, 24.64, 10.00, 0.00, and 24.86 for Q, VV, S, R/PL, and PS, respectively. The total time for Video 1 for Teacher A was 44.52. The time Teacher A used the selected MTP at Q was 2.97. The % duration for Q was calculated by 2.97/44.52=.066=6.67%. The same process was used to calculate the % duration for VV, S, R/PL, and PS.

Table 3.4
Matrix Query Teacher A Selected MTP at IWB Level of Use for Video 1

	Q	***VV***	***S***	***R/PL***	***PS***
SD	4	4	2	0	1
I	31	37	9	0	9
EI	15	24	4	0	7

The numbers in Table A.1.2 were obtained by a NVivo matrix query search performed on Teacher A, Video 1 for the IWB level of use and selected MTP. NVivo included all coded data for Teacher A, Video 1 and cross tabulated it with Teacher A selected MTP for Video 1. For example, in the row of SD and column of Q, the entry is 4. This means there were 4 instances in which Teacher A used the IWB at the support didactic while selected mathematics practice of questioning. In this instance, the teacher had students copy down an equation and asked the class if the equation was in slope-intercept form. In another example, for the row of I and the column of VV, the entry is 37. This means there were 37 instances in which Teacher A used the IWB at the interactive level while selecting mathematical practice of Verbal Visual. In this instance, Teacher A had a graph with a positive slope on the IWB. Teacher A asked students if the slope was positive or negative. Teacher A drew a ball on the left side of the graph and asked if the ball would roll up that graph.

Trustworthiness

For a qualitative study to have trustworthiness, it must have the following: credibility, transferability, dependability, and confirmability (Guba, 1981). Credibility, or internal validity of a study, is described by Merriam (1998) as the alignment of reality with the findings from a study. Lincoln and Guba (1985) concur that credibility is essential to have trustworthiness. This study ensured credibility by adopting a research method that is established and will answer the research question. Yin (2015) notes it is essential that the research method be aligned to the research question asked. This study utilized a case study research design method that aligns with the research question to answer.

Triangulation is acquiring data from different methods and, according to Guba (1981), the use of different methods to collect data aids in the cumulative effect of the data. In this study, I captured data from video stimuli, audio stimuli, and interviews. Participants were allowed the opportunity to either opt out of the study or leave the study at any time. Participation was strictly voluntary. Credibility was ensured by having an external reviewer review the study and the data collected during the study. Finally, this researcher provided a reflectivity section to reduce researcher bias into the study.

Transferability is the external validity or generalizability of a study. Merriam (1998) describes the extent to which results from one study can be applied to another situation is transferability. This study provided a thick rich description of the processes under investigation in this study, which will allow the reader to make a decision of the application of the findings to other settings.

Dependability is the ability of a study to reproduce similar results if it is repeated in the same setting, context, and participants. A detailed research design, data collection, and analysis procedures provided in this study allow a future researcher to replicate it.

Confirmability in a qualitative study deals with a study's objectivity. In order to ensure confirmability, triangulation of data sources to reduce investigator bias, admission of researcher beliefs and assumptions, and identification of shortcomings of this study are shared.

Reflectivity

The purpose for this section is to give my study reflectivity. Both of my parents were in the teaching profession: my mother was a special education teacher, and my father was a college instructor. Education has always been instilled in me as a priority, with learning as a lifelong process. I believe my background had an influence upon my chosen profession as a mathematics teacher. I am currently a high school mathematics teacher and an adjunct instructor at a local community college. I have been a teacher for ten years and have a Master's degree in Mathematics Education. I am currently in a graduate doctoral program in Mathematics Education, and my research interest is the use of technology and its impact in teaching mathematics. I am biased toward the use of technology in teaching and believe the use of it will aid in the student learning mathematics, but I do believe that the technology is not the only component in meaningful mathematical learning. I recall being one of the first teachers to have an IWB installed in my classroom. I remember feeling completely amazed at the capabilities of the technology, even then, for my teaching. I still believe they have the capacity to transform mathematics teaching to aid in student learning. I proceed with the understanding that I have a bias towards technology use in the classroom but will do my best to take an objective view through the systematic collection and analysis of data, as well as the review of my study by dissertation committee members.

Summary

The purpose of this study was to examine teachers' levels of use of the IWB in the algebra classroom. The literature indicates a need for research in this specific area. The educational community can benefit from the results of this study to inform instructional practices and aid in providing accountability for the use of the IWB in the classroom. The use of the TPACK model is an appropriate conceptual framework to utilize in this proposal, based upon its established use in the literature dealing with technology and IWB (Glover et al., 2007; Hofer & Grandgenett, 2012). Teacher interviews, the use of the MCOP^2, and video analysis were used to collect data. Descriptive statistics were utilized to analyze data from the video phase

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CHAPTER FOUR

FINDINGS

The purpose of this chapter is to present findings from the study. This chapter consists of a brief overview/restatement of the following: introduction, problem of the study, purpose of the study, and research question, and an in-depth analysis of each case will be presented.

IWBs are widely used in classrooms with the expectation teachers will use them to create positive learning environments for meaningful mathematical learning. A significant body of research indicates the positive influence IWB use has upon student engagement, motivation, and interactivity. Similarly, there is research to support the positive impact of IWB use for algebra instruction for the diverse levels of students in the algebra classroom (De Vita et al., 2014; Glover et al., 2005; Holmes, 2009; Swan et al., 2008; Wall et al., 2005). Even with positive indications in the literature supporting the IWB in the teaching and learning of algebra, how does the IWB impact effective mathematics teaching practices? In the NCTM's, *Principles to Action,* eight effective mathematics practices are identified to provide an outline to support mathematics teaching and learning. This is the area where this proposal will focus to answer the following research question: How does the use of an IWB impact an algebra teacher's implementation of selected mathematics teaching practices?

Algebra serves as a gateway course to subsequent higher-level mathematics courses, such as trigonometry and calculus (Atanda, 1999; Gulick & Scott, 2007; Moses

& Cobb Jr, 2001; Riley, 1998). Yet, students perform poorly on the South Carolina algebra course examinations (South Carolina Department of Education, 2015). This has consequences for students, teachers, schools, and districts, each whom are judged based on these tests scores. For example, students who perform poorly on the end-of-year examinations are subsequently unable to enroll in higher level mathematics courses (Baker et al., 2010). This limits their opportunities to be admitted to many four-year colleges and, also, to eventually have the background needed to work in many disciplines, such as science, technology, and engineering (Schiller & Muller, 2003). Additionally, in terms of equity issues, students from lower socioeconomic backgrounds and students of color are less likely to do well than their middle-income and white counterparts on such end-of-year examinations (Hemphill & Vanneman, 2011). Hence, it is important to find methods that provide broader access and success to more students in algebra courses (Tate, 1994). IWBs may be one innovation to provide support to teachers in the delivery of algebra content and aid students in meaningful mathematical learning opportunities.

Findings for Each Case

The findings section of this study will be presented in the following manner. Cases are presented as Teacher A, Teacher B, and Teacher C, and each case consists of 3 videos, specified as Video 1, Video 2, and Video 3. An outline table will be presented at the beginning of each case to illustrate the organization of the data.

Teacher A

Table 4.1
How data is organized for Teacher A

Demographics	Teacher A demographical information

Table 4.2	Table containing Teacher A interview responses describing use of IWB features.
Table 4.3, Table 4.4, Table 4.5.	Describes Teacher A IWB level of use and selected MTP
Table 4.6., Table 4.7, Table 4.8	Teacher A frequency of selected MTP at the IWB level of use
Table 4.9, Table 4.10, Table 4.11	Exemplars from NVivo query for teachers interactive level of IWB use and selected MTP of questioning and verbal visual
Table 4.12	Exemplars from NVivo code query for Teacher A Video 1 enhanced interactive level IWB use and selected MTP of questioning and verbal visual

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Demographics: Teacher A. The first teacher for this study will be identified as Teacher A. Teacher A has 10 years of teaching experience, a Bachelor's degree in Mathematics, became certified through a traditional college-based teaching licensure program, and is not National Board Certified (NBCT). Teacher A has used the IWB for five years and has not had any formal training on how to use the IWB. Teacher A describes learning her IWB knowledge as self-taught and peer learned via collaboration with her fellow teachers. Teacher A has an IWB in her current classroom, which Teacher A says is always used, averaging 5 hours per week. Teacher A rated herself a 4 on a scale of 1 to 5 when asked about her competence as an IWB user. Table 4.2 contains information obtained from the interview describing particular uses of features of the IWB.

Table 4.2
IWB uses Teacher A reported during interview

How often do you use the following IWB features?	**Never, Seldom, Frequently**
Mouse Function	Frequent
Highlighting	Frequent
Zoom	Frequent

Drag and Drop	Seldom
Coloring objects	Frequent
Using Gallery	Never
Drawing	Frequent
Snapshot	Seldom
Annotation	Frequent
Lesson Recording	Never
Virtual Keyboard	Never
Import picture, movie, etc.	Seldom
Spotlighting	Seldom
Handwriting recognition	Seldom
Screen shading	Seldom
Using internet	Frequent
Using Hyperlinks	Frequent

Based upon the responses from Teacher A during the interview, Teacher A indicated IWB level of uses of interactive and enhanced interactive. Teacher A said the level of use does depend on the topic the IWB is being used and would make sense to move from the different IWB levels of use, hence, Teacher A's indication of two levels of IWB use.

IWB Level of Use and Selected MTP IWB Video 1. The length of Video 1 for Teacher A was 44:52. The topic taught during the lesson was the product rule of exponents, the quotient rule of exponents, and the power rule of exponents. Teacher A had an $MCOP^2$ Student Engagement score of twenty-three and an $MCOP^2$ teacher facilitation score of fifteen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures “the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse” (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more teacher facilitation. Teacher A’s MCOP^2 score for Student Engagement of twenty-three indicates the student had a strong role in the classroom and engagement in the learning process, and an MCOP^2 teacher facilitation score of fifteen indicates Teacher A had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.3 describes Teacher A level of IWB use and selected MTP for Video 1.

Table 4.3
Teacher A IWB level of use and Selected MTP for Video

	IWB level of use			**Selected MTP**				
	SD*	I	EI	Q	VV	S	R/PL	PS
Frequency	7	16	15	50	65	15	0	17
% duration of Video	2.19	29.74	68.07	6.67	24.64	10.00	0.00	24.86

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher A used the IWB at the level of interactive or enhanced interactive level for the majority of Video 1 and most frequently utilized Q and VV as the selected MTP. Teacher A’s duration of use of the IWB was at the enhanced interactive level for the majority of the time for Video 1. A matrix query for above data was performed in NVivo for further analysis. Table 4.4 contains the frequency of Teacher A selected MTPs at the IWB level of use.

Table 4.4
Matrix Query Teacher A Selected MTP at IWB level of use for Video 1

	Q	**VV**	**S**	**R/PL**	**PS**

SD	4	4	2	0	1
I	31	37	9	0	9
EI	15	24	4	0	7

The matrix query for Teacher A selected MTP at IWB level of use for Video shows Teacher A most frequently used the IWB at the interactive level with selected MTP of Q and VV being the most frequently used MTP. The matrix query for Teacher A also indicates Teacher A used the IWB at the enhanced interactive less frequently than interactive, but more than support didactic. Also, the selected MTP of Q and VV were the most frequent MTP for the enhanced interactive level of use. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.5 contains exemplars from the NVivo code query search. The exemplar of "Can you have a negative exponent and it stay there?" illustrates an interactive level of IWB use along with selected MTP of Q and VV because Teacher A used the IWB feature of changing the color of the exponent to orange coloring, which is different from the base, denoted by black coloring.

Table 4.5
Exemplars for Teacher A Video 1 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	**Verbal visual**
How could you write an expression for that perimeter? So what two things are alike? When you say parenthesis what do you do first? What else do you have on the top? Can you have a negative exponent and it stay there?	Negative twenty-seven over x to the third. It stayed negative, exponents move to the bottom, the whole thing doesn't move to the bottom. Regular numbers don't move, just negative exponents.

This made the negative exponent stand out. Teacher A using this feature of the IWB is the Interactive level, as defined by Glover et al. (2005). Teacher A also asked the class if the problem contained a negative exponent and alluded to the problem on the board, which is the selected MTP of Q and VV. These two selected MTP were the most frequently occurring MTP during Video 1. An NVivo code query for specific content coded was performed for the enhanced interactive level of IWB use and selected *MTP* of Q and VV (NCTM, 2014). Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.6 contains exemplars obtained from the NVivo code query.

Table 4.6
Exemplars for Teacher A Video 1 Enhanced Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	**Verbal Visual**
When you're dividing what do you do with your exponents? A to the 3rd to the second is A to the? What do you do with your exponents when there's two separate ones? That's incorrect isn’t' it?	It doesn't have any exponents on the outside so you're just timesing. Because a negative times a negative is a positive times a negative makes it negative again. And then when you go back to an even number it turns it back positive. So any time you have even number exponent is going to turn positive. .

The exemplar of “When you’re dividing, what do you do with your exponents?” illustrates an enhanced interactive level of IWB use along with selected MTP of Q and VV because Teacher A used the IWB feature of changing the color of the exponents to red, which is different from the bases, which were in black. This made the negative exponents stand out. Teacher A also circles the red exponents in green, to further distance them from the base. During this particular problem, Teacher A allowed a student to come to the IWB and throw a ball at the IWB, which revealed the problem. Teacher A uses the IWB at the Enhanced Interactive level, as described by Glover et al.

(2005). Teacher A pointed to the IWB and also asked the class, "When you're dividing, what do you do with your exponents?" which is the selected mathematical practices of Q and VV (NCTM, 2014). These two selected MTP were the most frequently occurring MTP during Video 1.

IWB Level of Use and Selected MTP IWB Video 2. The length of the Video 2 for Teacher A was 44:10. The topic taught was multiply and divide numbers in scientific notation. In this video, Teacher A had an MCOP^2 student engagement score of eighteen, and MCOP^2 Teacher Facilitation score of twelve. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more teacher facilitation. Teacher A's MCOP^2 score for Student Engagement of eighteen indicate the student had a medium role in the classroom and engagement in the learning process, and an MCOP^2 Teacher Facilitation score of twelve indicates Teacher A had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.7 describes Teacher A level of IWB use and selected MTP for Video 2.

Table 4.7
Teacher A IWB level of use and Selected MTP for Video 2

	IWB level of use			Selected MTP				
	SD	I	EI	Q	VV	S	R/PL	PS
Frequency	0	15	2	69	70	8	5	2
% duration of Video	0.00	95.64	4.36	18.18	25.08	7.88	27.13	24.76

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

In Video 2, Teacher A used the IWB at the level of interactive for most of the lesson, 95%, and most frequently utilized Q and VV as the selected MTP. Q and VV were essentially the same. Teacher A's duration of use of the IWB was at the enhanced interactive level for only 4% during the Video 2.

A matrix query for above data was performed in NVivo for further analysis. Table 4.8 contains the frequency of Teacher A selected MTP at the IWB level of use for Video 2.

Table 4.8
Matrix Query Teacher A Selected MTP at IWB level of use for Video 2

	Q	**VV**	**S**	**R/PL**	**PS**
SD	0	0	0	0	0
I	69	70	8	5	2
EI	0	0	0	0	0

The matrix query for Teacher A selected MTP at IWB level of use for Video 2 shows Teacher A used the IWB at the interactive level with selected MTP of Q and VV being the most frequently used MTP. The matrix query for Teacher A also indicates Teacher A used the IWB at the enhanced interactive level none for any of the selected MTP. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.9 contains exemplars.

Table 4.9
Exemplars for Teacher A Video 2 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	Verbal Visual
What does Y cubed and Y eight make? What happens when you divide with exponent? What do we need to do? What is that exponent going to be? A negative? Regular numbers you're actually going to divide them? Exponent numbers you're gonna?	Anything to the zero power is one. So that whole big parentheses over there was all raised to zero. So the final answer is just one. No it is a way of writing really and large and really small numbers Notations, notation means a way of writing We can multiply and divide with scientific notation and you can follow the same rules as the exponent rule.

The exemplar of “What happens when you divide with exponent?” in Video 2 illustrates an interactive level of IWB use, along with selected MTP of Q because Teacher A used the IWB feature of erase and correct the problem on the IWB. Teacher A uses the IWB at an Enhanced Interactive level, as defined by Glover et al. (2005). Teacher A pointed to the IWB and also asked the class, “When you’re dividing, what do you do with your exponents?” which is the selected mathematical practices of Q and VV (NCTM, 2014). Similarly, exemplar of “We can multiply and divide with scientific notation, and you can follow the same rules as the exponent rule,” illustrates an interactive level of IWB use, along with selected MTP of VV, because Teacher A used the changing color feature when working out a scientific notation multiplication problem, defined by Glover et al. (2005) as the Interactive level of IWB. Teacher A pointed to the problem on the IWB, which is the VV MTP (NCTM, 2014). The two selected MTP of Q and VV were the most frequently occurring MTP during Video 2.

IWB Level of Use and Selected MTP IWB Video 3. The length of the third video for Teacher A was 31:37. The topics taught was factoring trinomials, and factoring by grouping. Teacher A had an MCOP^2 student engagement score of sixteen, and an

MCOP^2 Teacher Facilitation score of seventeen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse" and is scored from 0 to 27. A higher number means more Teacher Facilitation. Teacher A's MCOP^2 score for Student Engagement of sixteen indicate the student had a medium role in the classroom and engagement in the learning process, and an MCOP^2 teacher facilitation score of seventeen indicates Teacher A had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.10 describes Teacher A level of IWB use and selected MTP for Video 3.

Table 4.10
Teacher A IWB level of use and Selected MTP for Video 3

	IWB level of use			Selected MTP				
	SD	**I**	**EI**	**Q**	**VV**	**S**	**R/PL**	**PS**
Frequency	0	3	2	71	75	5	1	2
% duration of Video	0.00	93.68	6.32	26.03	48.53	53.08	13.02	27.62

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher A used the IWB at the level of Interactive or Enhanced interactive level for all of Video 3. Teacher A most frequently utilized Q and VV as the selected MTP. Teacher A's duration of use of the IWB was at the interactive level for the majority of the time for Video 3. A matrix query for above data was performed in NVivo for further analysis. Table 4.11 contains the frequency of Teacher A selected *MTP* at the IWB level of use.

Table 4.11
Matrix Query Teacher A Selected MTP at IWB level of use for Video 3

	Q	VV	S	R/PL	PS
SD	0	0	0	0	0
I	71	75	5	1	1
EI	0	0	0	0	1

The matrix query for Teacher A selected MTP at IWB level of use for Video 3 shows Teacher A most frequently used the IWB at the Interactive level with selected MTP of Q and VV being the most frequently used MTP. The matrix query for Teacher A also indicates Teacher A did not use the IWB at the Enhanced Interactive level or support didactic level. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and verbal visual VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.12 contains exemplars.

Table 4.12
Exemplars for Teacher A Video 3 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	Verbal Visual
What did you have to do? Did you find some numbers that work for that? Is there anything we should do to this one, before we do the x? Every time we factor we should do this? What should we do? Every time we factor we should do this? What's that?	Do the X thing Every single time look for a GCF first. Greatest Common Factor, like what's the biggest thing they have in common. Then we know there are all different pieces some you have a binomial, trinomial, sometimes polynomial.

The exemplar of “Is there anything we should do to this one, before we do the x?” illustrates an interactive level of IWB use along with selected MTP of Q. Teacher A used the IWB feature of changing the color of the pen while working out the problem. Teacher A’s use of this feature with the IWB is defined as the Interactive level by Glover et al. (2005). Teacher A also asked the class, “Is there anything we should do to this one, before we do the X?” alluded to the problem on the board, which is the selected MTP of Q and VV (NCTM 2014). In another example, the exemplar, “Do the X thing” illustrates an interactive level of IWB use along with VV because Teacher A used the highlighting feature of the IWB, which is what Glover et al. (2005) defines as the interactive level of IWB use. Teacher A was working out the problem and verbally alluding to the highlighted features, which is a VV MTP (NCTM, 2014). The two selected MTP of Q and VV were the most frequently occurring MTP during Video 3.

Summary: Teacher A. During the interview, Teacher A reported using the IWB at the levels of Interactive and Enhanced Interactive and self-rated themselves a four out of five of their use of the IWB. Table 4.13 contains the most salient findings for Teacher A selected MTP at IWB level of use for each. The table contains frequencies of Selected MTP at the levels of IWB use observed during the study. Teacher A in Video 1 appears to be consistent in her IWB level of use as reported during the interview and as observed in Video 1, but in Video 2 and Video 3, Teacher A did not use the IWB at the enhanced interactive level. Teacher A's MCOP^2 Teacher Facilitation score did not fluctuate at the IWB level of use of interactive or enhanced interactive. Teacher A was consistent in their MCOP^2 scores with the exception of Video 1 Student Engagement, in which the Teacher A had a score of 23 and used the IWB at the enhanced interactive level. This could be attributed to the topic taught during Video 1, which was more conducive to using the IWB at the enhanced interactive as opposed to Video 2 and Video 3. In Video 1, the topic of the lesson was multiplying polynomials. Teacher A used the IWB in an engaging manner. The students went to the IWB and threw a ball at it, which would reveal a problem for the class to work out. The student that solved the problem first would be allowed to throw the ball at the next problem. This lesson content may explain the high MCOP² Student Engagement score for Video 1. Similarly, this lesson content may offer an explanation for the distribution of the selected MTP of Q and VV being similar in frequencies for Teacher A at the interactive level of use for all three Videos, yet there are more instances of VV at the enhanced interactive level of use for Video 1. The observed selected MTP's and IWB level of use by Teacher A is also corroborated by responses during the interview, in which Teacher A said the IWB was used to actively

Table 4.13
Summary Data Teacher A

IWB Level of Use	
Self-Reported:	Observed:
Interactive and Enhanced Interactive	Interactive and Enhanced Interactive

Video Analysis

Video	MCOP²		IWB Level of Use	Selected MTP: Questioning	Selected MTP: Verbal Visual
1	Student Engagement	23	Interactive	31	37
	Teacher Facilitation	15	Enhanced Interactive	15	24
2	Student Engagement	18	Interactive	69	70
	Teacher Facilitation	12	Enhanced Interactive	0	0
3	Student Engagement	16	Interactive	71	75
	Teacher Facilitation	17	Enhanced Interactive	0	0

engage students by inviting them to the board to work out problems or even identify problems worked out incorrectly. During the interview, Teacher A discussed that using the polling feature of the IWB helped during review for material that was taught, along with the ability of the IWB to facilitate whole class questions for students to answer collaboratively.

Teacher B

The next section contains the findings for Teacher B. Table 4.14 is an example how the data is organized and will be presented in this section.

Table 4.14
Table illustrates how the data will be organized for Teacher B

Section	**Section Description**
Demographics	Demographic information about teacher.
Table 4.15	Table containing Teacher B interview responses describing use of IWB features.
Table 4.16, Table 4.17, Table 4.18	Describes teachers level of IWB use and selected MTP
Table 4.19, Table 4.20, Table 4.21	Teacher B frequency of Selected MTP at the IWB level of use
Table 4.22, Table 4.23, Table 4.24	Exemplars from the NVivo code query search for teachers interactive level of IWB use and selected MTP of Questioning and Verbal Visual

Demographics: Teacher B. The second teacher for this study will be identified as Teacher B. Teacher B has fifteen years of teaching experience, a bachelor's degree in mathematics, became certified in an alternative manner, and is not NBCT. Teacher B has used the IWB for ten years, and has no formal training on how to use the IWB. Teacher B describes learning how to use the IWB as self-taught and peer learned via collaboration with her fellow teachers. Teacher B has an IWB in their current classroom, which Teacher B says is always used on average of more than 7 hours per week. Teacher B rated themselves a three out of five when asked how competent they were as an IWB user. Table 4.15 represents information obtained from the interview describing particular uses of features of the IWB.

Table 4.15
IWB uses Teacher B reported during interview

How often do you use the following IWB features?	***Never, Seldom, Frequently***

Mouse Function	Frequent
Highlighting	Seldom
Zoom	Seldom
Drag and Drop	Frequent
Coloring objects	Frequent
Using Gallery	Seldom
Drawing	Frequent
Snapshot	Seldom
Annotation	Seldom
Lesson Recording	Seldom
Virtual Keyboard	Never
Import picture, movie, etc.	Seldom
Spotlighting	Seldom
Handwriting recognition	Seldom
Screen shading	Never
Using internet	Frequent
Using Hyperlinks	Seldom

Based upon the responses from Teacher B during the interview, the IWB level of use are interactive and enhanced interactive. Teacher B said the level of use does depend on how the IWB is being used for a certain topic, and would make sense to move from the different IWB levels of use.

Interactive Whiteboard level of use and Selected MTP IWB Video 1. The length of the first Video for Teacher B was 33:43. The lesson taught during this video was a review of the following topics: Find slope of a line given a graph and points, find the slope and y-intercept given an equation, find the x and y-intercepts given an equation, and write the equation of a line in slope intercept form given a point(s) on the line. Teacher B had an MCOP^2 Student Engagement score of nineteen, and MCOP^2 Teacher

Facilitation score of seventeen. Teacher B had an MCOP^2 Student Engagement score of nineteen, and MCOP^2 Teacher Facilitation score of seventeen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse", and is scored from 0 to 27. A higher number means more Teacher Facilitation. Teacher B's MCOP^2 score for Student Engagement of seventeen indicated the student had a medium role in the classroom and engagement in the learning process, and MCOP^2 Teacher Facilitation score of fifteen indicates Teacher B had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.16 describes Teacher B level of IWB use and Selected MTP for Video 1. Teacher B used the IWB at the level of interactive or enhanced interactive level for the majority of Video 1, and most frequently utilized Q and VV as the selected MTP. Teacher B duration of use of the IWB was at the interactive level for the majority of the time for Video 1.

Table 4.16
Teacher B IWB level of use and Selected MTP for Video 1

	IWB level of use			***Selected MTP***				
	SD	**I**	**EI**	**Q**	**VV**	**S**	**R/PL**	**PS**
Frequency	1	8	12	167	144	12	6	2
% duration of Video	4.00	88.37	7.12	25.09	54.36	84.17	58.91	9.74

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

. A matrix query for above data was performed in NVivo for further analysis. Table 4.17 contains the frequency of Teacher B selected MTP at the IWB level of use.

Table 4.17
Matrix Query Teacher B Selected MTP at IWB level of use for Video 1

	Q	**VV**	**S**	**R/PL**	**PS**
SD	6	5	1	1	0
I	152	134	9	3	2
EI	9	5	2	2	0

The matrix query for Teacher B selected MTP at IWB level of use for Video 1 shows Teacher B most frequently used the IWB at the interactive level with selected MTP of Q and VV being the most frequently used MTP. The matrix query for Teacher B also indicates Teacher B used the IWB at the enhanced interactive less frequent than interactive, but more than support didactic. Also the selected MTP of Q and VV were the most frequent MTP for the enhanced interactive level of use. An NVIVO query for specific content at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.18 contains exemplars.

Table 4.18
Exemplars for Teacher B Video 1 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

<u>Questioning</u>	***<u>Verbal Visual</u>***
Am I going to go up or down to get to this point? What does that three represent? So going to the right means what? Now do we automatically have to go from the bottom to the top every time? What if I wanted to start here?	So the y values represented the rise the x value represent the run. And that's why the y’s need to be on top. So here we go let's plug that in. I'm not giving you Slope, I'm giving you two points. But you're equipped with all the information you need to find m and b, the Slope.

So does it matter which way I'd go to find that slope?

The exemplar of "So going to the right means what?" illustrates an interactive level of IWB use because Teacher B used the IWB feature of a premade Cartesian template on the board to show students how to graph out the slope problem. Teacher B using this feature of the IWB is what Glover et al. (2005) defined as the Interactive level of IWB. Teacher B also asked the class, "So going to the right means what?", and alluded to the problem on the board, which is the selected MTP of Q and VV (NCTM 2014).

In another example, Teacher B used selected MTP of Q and VV, as demonstrated with the exemplar of "I'm not giving you slope, I'm giving you two points. But you're equipped with all the information you need to find m and b, the slope. This illustrates an interactive level of IWB use (Glover et al., 2005) along with selected MTP of Q and VV (NCTM, 2014). These two selected MTP were the most frequently occurring MTP during Video 1.

Interactive Whiteboard level of use and Selected MTP IWB Video 2. The length of the Video 2 for Teacher B was 36:48. The topics taught was determining if ordered pairs are a solution to a linear inequality and graphing a linear inequality. Teacher B had an MCOP^2 student engagement score of nineteen and MCOP^2 Teacher Facilitation score of fifteen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse", and is scored from 0 to 27. A higher number means more teacher facilitation. Teacher B MCOP^2 score for Student Engagement of fifteen indicate the student had a medium role in the classroom and engagement in the learning process, and MCOP^2 Teacher Facilitation score of fifteen indicates Teacher B had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.19 describes Teacher B level of IWB use and selected MTP for Video 2.

Table 4.19
Teacher B IWB level of use and Selected MTP for Video 2

	IWB level of use			Selected MTP				
	SD	***I***	***EI***	***Q***	***VV***	***S***	***R/PL***	***PS***
Frequency	5	24	0	71	36	18	4	0
% duration of Video	13.00	87.00	0.00	24.32	28.77	49.32	8.11	0.00

**SD-Support Didactic, I-Interactive, E.I.-Enhanced Interactive, Q-Questioning, V.-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher B used the IWB at the level of interactive for the majority of Video 2, and most frequently utilized Q and VV as the selected MTP. Teacher B duration of use of the IWB was at the interactive level for the majority of the time for Video 2. A matrix query for above data was performed in NVivo for further analysis. Table 4.20 contains the frequency of Teacher B selected MTP at the IWB level of use for Video 2.

Table 4.20
Matrix Query Teacher B Selected MTP at IWB level of use for Video 2

	Q	***VV***	***S***	***R/PL***	***PS***
SD	0	0	3	3	0
I	71	36	15	1	0
EI	0	0	0	0	0

The matrix query for Teacher B selected MTP at IWB level of use for Video 2 shows Teacher B most frequently used the IWB at the interactive level with selected

MTP of Q being the most frequently used, followed by VV. The matrix query for Teacher B also indicates Teacher B did not use the IWB at the enhanced interactive. An NVIVO query for specific content at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.21 contains exemplars.

Table 4.21
Exemplars for Teacher B Video 2 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	***Verbal Visual***
What's my constant product? Do you think the inverse variations are going to go through the middle? What is the equation for the inverse variation? Okay so if we're dealing with inverse variation is it a constant ratio or a constant product?	And it's very important that I do this because I want to show the person who's reading my graph that my graphs going up each lines going up by two units and not one ok. I think it's very important to point out here see how this line right here see has go in and it is getting closer to that Y-axis. It's never going to touch it.

The exemplar of "What's my constant product?" illustrates an interactive level of IWB use because Teacher B used a cut and paste feature of the IWB to put the rule on the screen for the constant product while discussing the problem. This action is what Glover et al (2005) define as the interactive level of IWB use because the cut and paste feature is an action of IWB use at the interactive level. Teacher B asked the class a question and pointed to it on the IWB, which is selected MTP's of Q and VV (NCTM, 2014) In another example, Teacher B utilized the selected MTP of VV, demonstrated by the exemplar, "And it's very important that I do this because I want to show the person who's reading my graph that my graphs going up each lines going up by two units and not one, ok?" illustrates an interactive level of IWB use, because Teacher B used a premade template for graphing (Glover et al., 2005). Teacher B used the MTP of Q and

VV, because the teacher alluded to the problem by pointing at it, and showing students how to properly graph slope, while asking questions to discern student learning (NCTM, 2014). These two selected MTP were the most frequently occurring MTP during Video 2.

Interactive Whiteboard level of use and Selected MTP IWB Video 3. The length of the third Video for Teacher B was 37:21. The topics taught were Identify the constant of an inverse variation, and write the inverse variation equation given points, a table, or partial points. Teacher B had an $MCOP^2$ Student Engagement score of fourteen, and $MCOP^2$ Teacher Facilitation score of seventeen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse", and is scored from 0 to 27. A higher number means more Teacher Facilitation. Teacher B's $MCOP^2$ score for Student Engagement of fourteen indicate the student had a medium role in the classroom and engagement in the learning process, and $MCOP^2$ teacher facilitation score of fifteen indicates Teacher B had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.22 describes Teacher B level of IWB use and selected MTP for Video 3.

Table 4.22
Teacher B IWB level of use and Selected MTP for Video 3

	IWB level of use			*Selected MTP*				
	SD	**I**	**EI**	**Q**	**VV**	**S**	**R/PL**	**PS**
Frequency	2	17	0	60	26	19	8	1
% duration of	17.28	82.72	0.00	10.72	48.26	45.48	27.47	0.00

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher B used the IWB at the level of interactive for the majority of Video 3, and most frequently utilized Q as the selected MTP. Teacher B duration of use of the IWB was at the interactive level for the majority of the time for Video 3, followed by support didactic, and enhanced interactive last. A matrix query for above data was performed in NVivo for further analysis. Table 4.23 contains the frequency of Teacher B selected MTP at the IWB level of use.

The exemplar of "What does rise over run represent?" illustrates an interactive level of IWB use because Teacher B had the definition of rise over run on the board, along with a premade graph example of a line (Glover, 2005). Teacher B asking the question to the class, while pointing to the IWB are selected MTP's of Q and VV (NCTM, 2014). Teacher B in another exemplar said, "Similar to a linear equation, but uses inequality symbol…greater than, less than. That's the only difference between the two." This exemplar illustrates an interactive level of IWB use along with selected MTP of VV because Teacher B used a different color to write out the inequality symbol, which is an interactive level of IWB use (Glover et al., 2005). Teacher B alluded to the problem worked out on the IWB, which is a selected MTP of VV (NCTM, 2014). These two selected MTP were the most frequently occurring MTP during Video 3.

Table 4.23
Matrix Query Teacher B Selected MTP at IWB level of use for Video 3

	Q	**VV**	**S**	**R/PL**	**PS**
SD	13	3	4	2	1

I	47	23	15	6	0
EI	0	0	0	0	1

The matrix query for Teacher B selected MTP at IWB level of use for Video 3 shows Teacher B most frequently used the IWB at the interactive level with selected MTP of Q the most frequently used MTP, followed by VV. The matrix query for Teacher B also indicates Teacher B used the IWB at the support didactic less than the interactive level but more than the enhanced interactive level. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.24 contains exemplars.

Table 4.24
Exemplars for Teacher B Video 3 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	**Verbal Visual**
So what does negative 1 represent?	Similar to a linear equation, similar to a linear equation but uses inequality symbol similar to a linear equation but uses an inequality symbol. If you remember those symbols less than greater than less than or equal to greater than or equal to. That's the only difference between the two. So the linear inequality is similar to a linear equation but instead of an equal sign and uses those inequality symbols less than, greater than, less than or equal to, greater than or equal to
Is this ordered pair a solution to this inequality?	
What does rise over run represent?	
Is this inequality set up to graph?	
What does it mean to rise negative two?	

Data from the table above illustrate Teacher B reported using the IWB at the interactive

Summary Teacher B. During the interview, Teacher B reported using the IWB at the levels of Interactive and Enhanced Interactive, and self-rated themselves a 3 out of five of their use of the IWB. Table 4.25 contains the most salient findings for Teacher B selected MTP at IWB level of use for each Video.

Table 4.25
Summary Teacher Data B

IWB Level of Use

Self-Reported:	Observed:
Interactive and Enhanced Interactive	Interactive and Enhanced Interactive

Video Analysis

Video	MCOP[2]		IWB Level of Use	Selected MTP	
				Questioning	Verbal Visual
1	Student Engagement	19	Interactive	152	134
	Teacher Facilitation	17	Enhanced Interactive	9	5
2	Student Engagement	15	Interactive	71	36
	Teacher Facilitation	15	Enhanced Interactive	0	0
3	Student Engagement	14	Interactive	47	23
	Teacher Facilitation	17	Enhanced Interactive	0	0

and enhanced interactive level, but the observed level of IWB use is only interactive for Video 2 and Video 3. Teacher B did have instances of using the IWB at the enhanced interactive level during Video 1. These differences of levels of IWB use by Teacher B may be explained by how the topic was taught during Video 1. Note the MCOP [2] score for Student Engagement for Video 1 is 19 and is higher than for both Video 2 and Video 3. Teacher B allowed two students to come to the IWB and interact with the IWB by working out problems during Video 1, which scores at an enhanced interactive level of use, according to Glover et al. (2005). This behavior was corroborated during the interview with Teacher B. Teacher B alluded to the fact of having students get involved in using the IWB in solving math problems, and specifically a jeopardy like game to work out review situations of content. Teacher B tended to have the same frequencies of occurrence of Q and VV during Video 1, as opposed to Video 2 and Video 3. Video 2 and Video 3 were lesson where Teacher B was preparing students for either a test or quiz the next day. This type of lesson would lend itself less to an enhanced interactive level of use for the IWB, to have Teacher B asking more questions as a formative assessment.

Teacher C Demographics. The third teacher for this study will be identified as Teacher C. Table 4.26 illustrates how the data will be organized for Teacher C. Teacher C has twenty years of teaching experience, and bachelor's degree in elementary mathematics. Teacher C became certified in the traditional manner elementary education, added on secondary mathematics, and is NBCT. Teacher C has used the IWB for 8 years, and has no formal training on how to use the IWB. Teacher C describes learning how to use the IWB as self-taught and peer learned via collaboration with fellow teachers. Teacher C has an IWB in her current classroom, which teacher C says is always used, on average of more than 7 hours per week. Teacher C rated themselves a 4 out of 5 when asked how competent as an IWB user.

Table 4.26
Table illustrates how the data will be organized for Teacher C

Section	**Section Description**

Demographics	Demographical information about that teacher.
Table 4.27	Table contains teacher C interview responses describing use of IWB features.
Table 4.28, Table 4.29, Table 4.30	Describes teachers level of IWB use and Selected MTP
Table 4.31, Table 4.32, Table 4.33	Teacher C frequency of that teacher's use of Selected MTP at the IWB level of use
Table 4.34, Table 4.35, Table 4.36	Contains exemplars from the NVIVO code query search for teachers interactive level of IWB use and Selected MTP of Questioning and Verbal Visual
Table 4.37	Contains exemplars from the NVIVO code query search for teachers enhanced interactive level of IWB use and Selected MTP of Questioning and Verbal Visual

Table 4.27 contains information obtained from the interview describing particular uses of features of the IWB. Based upon the responses from teacher C during the interview, the IWB level of use are interactive and enhanced interactive. Teacher C said the level of use does depend on how the IWB is being used for a certain topic, and would make sense to move from the different IWB levels of use.

Table 4.27
IWB uses Teacher C reported during interview

How often do you use the following IWB features?	***Never, Seldom, Frequently***
Mouse Function	Frequent
Highlighting	Frequent
Zoom	Seldom
Drag and Drop	Frequent
Coloring objects	Seldom
Using Gallery	Frequent
Drawing	Frequent
Snapshot	Frequent
Annotation	Frequent

Lesson Recording	Never
Virtual Keyboard	Never
Import picture, movie, etc.	Frequent
Spotlighting	Seldom
Handwriting recognition	Never
Screen shading	Never
Using internet	Frequent
Using Hyperlinks	Frequent

Interactive Whiteboard level of use and Selected MTP IWB Video 1. The length of the first Video for Teacher C was 40:54. The lesson was a review of the following topics: parent function translations, geometric and arithmetic patterns, and radical notation. Teacher C had an MCOP^2 Student Engagement score of eighteen, and MCOP^2 Teacher Facilitation score of seventeen. Teacher C had an MCOP^2 Student Engagement score of eighteen, and MCOP^2 Teacher Facilitation score of seventeen. Student Engagement measures “the role of the student in the classroom and their engagement in the learning process” (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures “the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse”, and is scored from 0 to 27. A higher number means more teacher facilitation. Teacher C MCOP^2 score for Student Engagement of eighteen indicate the student had a medium role in the classroom and engagement in the learning process, and MCOP^2 Teacher Facilitation score of seventeen indicates Teacher C had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.28 describes Teacher C level of IWB use and selected MTP for Video one.

Table 4.28
Teacher C IWB level of use and Selected MTP for Video 1

	IWB level of use			*Selected MTP*				
	SD	***I***	***EI***	***Q***	***VV***	***S***	***R/PL***	***PS***
Frequency	7	9	2	64	53	4	4	1
% duration of Video	46.93	28.31	11.04	10.97	29.27	20.65	28.23	6.52

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher C used the IWB most frequently at the interactive level followed by the support didactic during Video 1, and most frequently utilized Q, followed by VV as the selected MTP. Teacher C duration of use of the IWB was at the support didactic level followed by the interactive level for Video 1. A matrix query for above data was performed in NVivo for further analysis. Table 4.29 contains frequency of Teacher C selected MTP at the IWB level of use.

Table 4.29
Matrix Query Teacher C Selected MTP at IWB level of use for Video 1

	Q	***VV***	***S***	***R/PL***	***PS***
SD	0	0	0	0	0
I	48	41	3	3	1
EI	16	12	1	1	0

The matrix query for Teacher C selected MTP at IWB level of use for Video 1shows Teacher C most frequently used the IWB at the interactive level with selected MTP of Q and VV being the most frequently used MTP. The matrix query for Teacher C also indicates Teacher C used the IWB at the enhanced interactive less frequent than interactive, but more than support didactic. Also the selected MTP of Q and VV were the most frequent MTP for the enhanced interactive level of use. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.30 contains exemplars.

Table 4.30
Exemplars for Teacher C Video 1 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	***Verbal Visual***
What kind of pattern is that?	I'm going down. so I only got two options I can either be dividing or subtracting.
How do I know if I'm going up or down?	
What does the arithmetic mean?	Common difference just means how it's changing add or subtract.

The exemplar of "What kind of pattern is that?", illustrates an interactive level of IWB use because Teacher C had the problem already on the board, and used a different color to help the students identify the type of pattern, which is identified by Glover et al. (2005) as an interactive level of IWB use. Teacher C asking the question, and pointing to the IWB are selected MTP's of Q and VV (NCTM, 2014). Teacher C in another exemplar, illustrated the pattern of the sequence, and asked the class, "I'm going down. So I only got two options I can either be dividing or subtracting." This example demonstrates what Glover et al. (2005) identifies as an interactive level of IWB use and the NCTM (2014) selected MTP of VV. These two selected MTP were the most frequently occurring MTP during Video 1. An NVIVO code query for specific content coded was performed for the enhanced interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.31 contains exemplars.

Table 4.31
Exemplars for Teacher C Video 1 Enhanced Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	***Verbal Visual***
And tell me what happens to my graph? What happened to my graph when I just left the two, and not the four? What does y intercept mean?	It moved it to the right two. So I know I went to the right two times. Now I need to see what the four is going to do. So when I go back and put the four in, and maybe when I go back and put the four in.

The exemplar of "What happened to my graph when I just left the two in, and not the four?" illustrates an enhanced interactive level of IWB use because Teacher C used the IWB feature of bringing in the TI-83 graphing calculator onto the IWB screen to make the calculations and show the graphs. Glover et al (2005) identifies bringing in software while using the IWB as an enhanced interactive level of use. Teacher C asking the class the question and refereeing to the IWB are selected MTP of Q and VV (NCTM, 2014).

Interactive Whiteboard level of use and Selected MTP IWB Video 2. The length of the Video 2 for Teacher C was 43:20. The topics taught were the product rule of exponents, power rule of exponents, and the zero exponent rule. Teacher C had an $MCOP^2$ Student Engagement score of sixteen, and $MCOP^2$ Teacher Facilitation score of fourteen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse", and is scored from 0 to 27. A higher number means more teacher facilitation. Teacher C $MCOP^2$ score for Student

Engagement of sixteen indicate the student had a medium role in the classroom and engagement in the learning process, and $MCOP^2$ Teacher Facilitation score of fourteen indicates teacher C had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.32 describes Teacher C level of IWB use and selected MTP for Video 2.

Table 4.32
Teacher C IWB level of use and Selected MTP for Video 2

	IWB level of use			Selected MTP				
	SD	***I***	***EI***	***Q***	**VV**	***S***	***R/PL***	***PS***
Frequency	4	13	6	47	53	5	7	1
% duration of Video	9.27	75.83	21.92	16.67	46.97	42.37	33.68	21.03

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher C used the IWB at the level of interactive or enhanced interactive level for the majority of Video 1, and most frequently utilized VV and Q as the selected MTP. Teacher C duration of use of the IWB was at the interactive level for the majority of the time for Video 2, followed by the enhanced interactive.

A matrix query for above data was performed in NVivo for further analysis. Table 4.33 contains the frequency for Teacher C selected MTP at the IWB level of use for Video 2.

Table 4.33
Matrix Query Teacher C Selected MTP at IWB level of use for Video 2

	Q	***VV***	***S***	***R/PL***	***PS***
SD	0	0	0	0	0
I	41	48	3	7	1
EI	6	5	2	0	0

The matrix query for Teacher C selected MTP at IWB level of use for Video 2 shows Teacher C most frequently used the IWB at the interactive level with selected MTP of VV and Q being the most frequently used MTP. The matrix query for Teacher C also indicates Teacher C used the IWB at the enhanced interactive less frequent than interactive, but more than support didactic. Also, the selected MTP of Q and VV were the most frequent MTP for the enhanced interactive level of use. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.34.

Table 4.34
Exemplars for Teacher C Video 2 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	***Verbal Visual***
Anything raised to the zero power is?	I took this whole entire problem and raised it to the zero power. So that means it turned everything there into a plain old one. All right. Because everything was raised to zero power it means that it turned it all to a one.
What happens when I raise something to an exponent and then I raise it to an exponent again?	
What's going to happen when I have multiple things that I'm raising to that exponent?	Power to power means that I'm going to rise to an exponent and then I'm going to raise it to another.

The exemplar of "Anything raised to the zero power is?" illustrates an interactive level of IWB because Teacher C used a black background, and yellow for the color of the variables. Teacher C made the zero exponent in white, which helped it stand out. This use of colors on the IWB is what Glover et al. (2005) describes as the interactive level of IWB use. Teacher C asking the class this question, and alluding to the IWB are selected MTP of Q and VV (NCTM, 2014). The exemplar of "power to power means that I'm going to rise to an exponent and then I'm going to raise it to another. Exponent for example its going to look like X squared to the third power," illustrates an interactive level of IWB use because Teacher C used different font colors for the exponents to help them stand out (Glover et al., 2005). Teacher C referenced the IWB during working out the problem (NCTM, 2014) and is a selected MTP of VV. These two selected MTP were the most frequently occurring MTP during Video 2.

Interactive Whiteboard level of use and Selected MTP IWB Video 3. The length of the Video 3 for Teacher C was 37:49. A test review for the following topics were taught: product rule of exponents, power rule of exponents, and the zero exponent rule. Teacher C had an $MCOP^2$ Student Engagement score of twenty-two, and $MCOP^2$ Teacher Facilitation score of nineteen. Teacher C had an $MCOP^2$ Student Engagement score of twenty-two, and $MCOP^2$ teacher facilitation score of nineteen. Student Engagement measures "the role of the student in the classroom and their engagement in the learning process" (Gleason et al., 2015) and is scored from 0 to 27. A higher number means more student engagement. Teacher Facilitation measures "the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse" (Gleason et al., 2015, p. 4), and is scored from 0 to 27. A higher number means more teacher facilitation. Teacher C $MCOP^2$ score for Student Engagement of twenty-two indicate the student had a strong role in the classroom and engagement in the learning process, and $MCOP^2$ Teacher Facilitation score of nineteen indicates Teacher C had a medium role for providing structure for the lesson and guiding problem solving and classroom discourse. Table 4.35 describes Teacher C level of IWB use and selected MTP for Video 3.

Table 4.35
Teacher C IWB level of use and Selected MTP for Video 3

	IWB level of use			*Selected MTP*				
	SD	***I***	***EI***	***Q***	***VV***	***S***	***R/PL***	***PS***
Frequency	3	8	5	47	53	2	7	10
% duration of Video	13.75	47.76	38.02	22.37	42.11	27.49	63.18	38.24

**SD-Support Didactic, I-Interactive, EI-Enhanced Interactive, Q-Questioning, VV-Verbal Visual, S-Structure, R/PL-Review/Prior Learning, PS-Productive Struggle, MTP-Mathematics Teaching Practices*

Teacher C used the IWB at the level of interactive or enhanced interactive level for the majority of Video 3, and most frequently utilized Q and VV as the selected MTP. Teacher C duration of use of the IWB was at the interactive level most, followed by enhanced interactive, and support didactic for Video 3. A matrix query for above data was performed in NVivo for further analysis. Table 4.36 contains frequency of Teacher C selected MTP at the IWB level of use.

Table 4.36
Matrix Query Teacher C Selected MTP at IWB level of use for Video 3

	Q	***VV***	***S***	***R/PL***	***PS***
SD	2	2	0	0	0
I	38	35	1	5	0
EI	7	16	1	2	10

The matrix query for Teacher C selected MTP at IWB level of use for Video 3 shows Teacher C most frequently used the IWB at the interactive level with selected MTP of Q and VV being the most frequently used MTP. The matrix query for Teacher C also indicates Teacher C used the IWB at the enhanced interactive less frequent than interactive, but more than support didactic. Also the selected MTP of Q and VV were the most frequent MTP for the enhanced interactive level of use. An NVivo query for specific content coded at the interactive level of IWB use and selected MTP of Q and

VV. Q and VV were the most frequently observed selected MTP and is the rational for selecting as exemplars. Table 4.37 has exemplars.

Table 4.37
Exemplars for Teacher C Video 3 Interactive level IWB use and Selected MTP of Questioning and Verbal Visual

Questioning	***Verbal Visual***
Tell me what you're supposed to do? And what did you get? What do I do with them?	So you've got to make sure any time you have that parentheses with the little exponent you're distributing you're giving it out just like we've done says Chapter 1. Any time we put something besides parentheses you distribute and distribute Means multiplying.

The exemplar of “What do I get when I raise X to the two to the three?”, illustrates an interactive level of IWB use because Teacher C had imported a PDF with the problems already written/typed out on the board (Glover et al., 2005). Teacher C asking the class the question, “What do I get when I raise X to the two to the three?” and referenced the problem on the IWB is what the NCTM (2014) describes as the selected MTP’s Q and VV. The selected MTP of Q and VV were the most frequently occurring MTP during Video 3.

Summary: Teacher C. During the interview, Teacher C reported using the IWB at the levels of Interactive and Enhanced Interactive, and self-rated themselves a 4 out of five of their use of the IWB. Table 4.38 contains the most salient findings for Teacher C selected MTP at IWB level of use for each video, and frequencies of selected MTP at the levels of IWB use observed during the study.

Table 4.38
Summary Data Teacher C

IWB Level of Use

Self-Reported:	Observed:
Interactive and Enhanced Interactive	Interactive and Enhanced Interactive

Video Analysis

Video	MCOP[2]		IWB Level of Use	Selected MTP: Questioning	Selected MTP: Verbal Visual
1	Student Engagement	18	Interactive	48	41
	Teacher Facilitation	17	Enhanced Interactive	16	12
2	Student Engagement	16	Interactive	41	48
	Teacher Facilitation	14	Enhanced Interactive	6	5
3	Student Engagement	22	Interactive	38	35
	Teacher Facilitation	19	Enhanced Interactive	7	16

Teacher C self-reported using the IWB at both the interactive and enhanced interactive level. In all videos, Teacher C appears to be consistent in their IWB level of use as reported during the interview, and Teacher C had more instances of enhanced interactive than the other two teachers, but this did not seem to show as an increase in MCOP[2] scores. Teacher C used the IWB at the interactive level more frequently than enhanced interactive level as observed in Video1, Video 2 and Video 3. Also, the frequencies of selected MTP of Q and VV are similar for Teacher C at the interactive and enhanced interactive level of use for all three videos, with the exception of Video 3. This is an interesting finding, and believe it to be attributed to how Teacher C was using the IWB. Note the MCOP [2] score for student engagement score was highest during Video 3.

Teacher C was using an interactive online game called Kahoot on the IWB. This game would present math questions to the class on the IWB, which students would answer on their laptops. Students would get a higher rating if they answered the question faster than their classmates. The results would be displayed on the IWB, and the teacher had an opportunity to work out the problem to answer questions. The students seemed excited and enjoyed this activity, and hence the higher student engagement score. Teacher C noted in the interview their/her use of the TI-83, a Jeopardy game, and the Kahoot game on the IWB and felt it helped the students be more engaged and learn the math content, or even use it to reteach/review for quizzes and tests.

All Three Cases

To help better address the research question and findings, this section offers Table 4.39, a table of all three teacher's data, to allow for an easier review across the three cases.

Table 4.39
All Teachers Data

Teacher	Video	MCOP^2		Q		VV	
		SE	TF	I	EI	I	EI
A	1	23	15	31	15	37	24
	2	18	12	69	0	70	0
	3	16	17	71	0	75	0
	Average	19	14.7	57	5	60.7	8
B	1	19	17	152	9	134	5
	2	15	17	71	0	36	0
	3	15	15	47	0	23	0
	Average	16.3	16.3	90	3	64.3	1.7
C	1	18	17	48	16	41	12
	2	16	14	41	6	48	5
	3	22	19	38	7	35	16
	Average	18.7	16.7	42.3	9.7	41.3	11

Key Findings

Of the initial eight MTP, the pilot study identified only five being used and were the focus of this study. Questioning and verbal visual were the most observed MTP identified in classrooms of algebra teachers using the IWB mostly at the interactive level, with some instances of enhanced interactive. The findings from comparing Teacher A, Teacher B, and Teacher C as presented in the above table are as follows. The MCOP ^{2} Student Engagement scores were slightly higher than the MCOP^2 scores for Teacher Facilitation. Teacher A and Teacher B highest MCOP^2 Student Engagement score aligned moderately when the IWB was used at the enhanced interactive level. This seemed to be the case for Teacher C, whose highest MCOP ^{2} SE and Teacher Facilitation scores came with lower numbers on interactive and enhanced interactive than their mid-level MCOP^2 scores. This concludes the analysis and findings for the study. Chapter Five will discuss the findings and expound on their importance, meaning, and significance.

CHAPTER FIVE

DISCUSSION

The purpose of Chapter Five is to discuss the findings. The conclusions, implications, and future research will be discussed. First, the conclusions will consist of a detailed interpretation of how the findings fit into the larger body of literature and the conceptual framework. Next, the implications to highlight the importance of the interpretations and discussion to theory, research, and practice are discussed. Last, future recommendations will be presented.

Three Key Conclusions from the Study

Three conclusions will be presented in this section: (1) a conclusion pertaining to observed selected MTP of Q and VV will be discussed, followed by (2) a conclusion on observed IWB level of use, and last, (3) a conclusion that addresses unexpected observations.

Key Conclusion 1: Observed selected mathematical practices of Q and VV. The first section of the conclusions consists of a discussion of results observed during the study, and an explanation citing the literature. All 3 teachers used the selected MTP of Q and VV most of the time during the study. Figures 1, 2, and 3 display teacher's selective MTP across all three video observations.

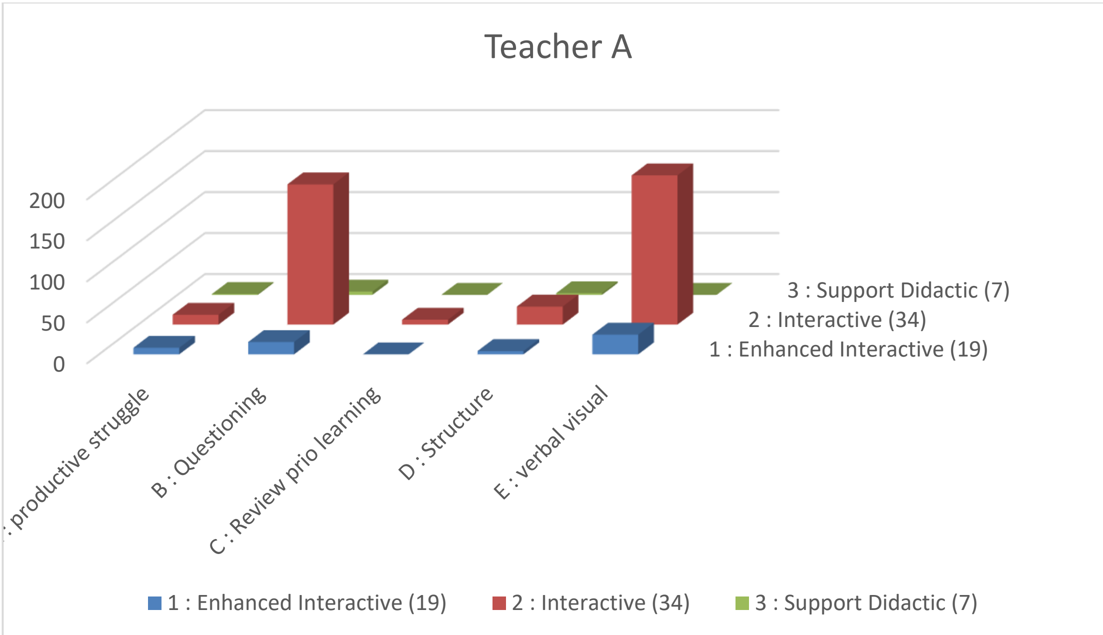

Figure 5.1 Teacher A selected MTP

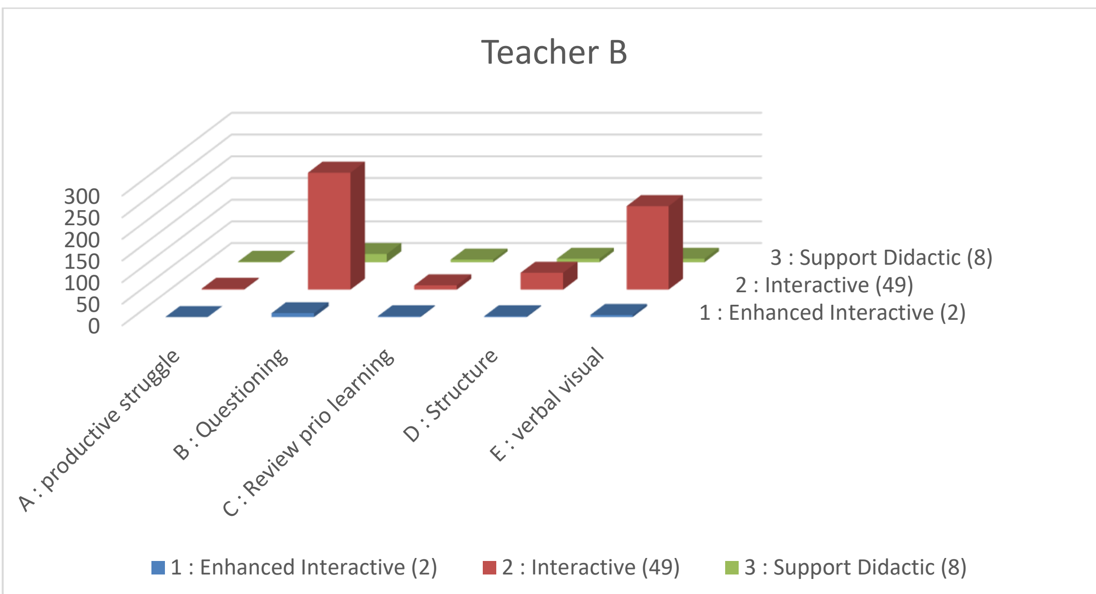

Figure 5.2 Teacher B selected MTP

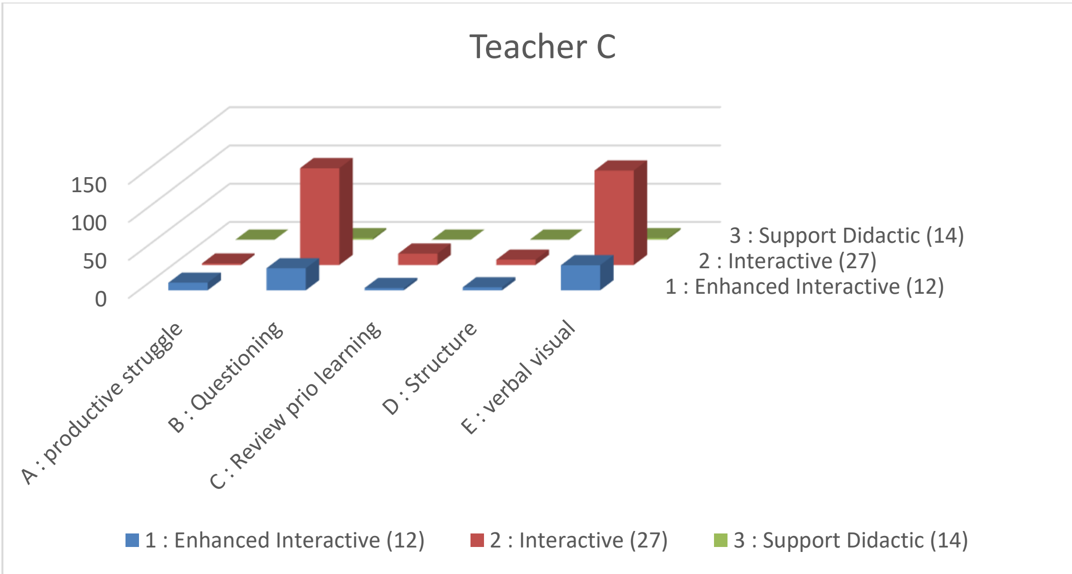

Figure 5.3 Teacher C selected MTP

The selected MTP of questioning and verbal visual are clearly shown by the graphs as the most frequently occurring for all three teachers. The NCTM (2014) cites purposeful use of questions to assess and advance student reasoning and sense making about mathematical ideas and relationships. The typical types of questions used by teachers were questions where the teacher would provide guidance to the class while presenting a lesson. For instance, "Three x plus two x equals?", and "Is the equation in slope intercept form?" are examples of guiding questions asked to student(s) by teachers. The teachers would wait for a response from the student(s), and depending on the response, the teacher would either ask another question(s) or proceed to the next problem. The use of questioning creates dialogue opportunities between the class and teacher, and between students, thus facilitating whole class discussion of mathematical ideas NCTM (2014). The types of questions observed were not only a guiding type of question, rather questions that forced the student to think at a deeper level, thus forcing the student(s) to work with the concepts at a higher cognitive level. For instance, "how is this graphing problem different from the previous graphing problem", and "where is the mistake in the problem", are two examples observed by teachers. The teachers used these types of questions to make learning active to engage the learner with challenging tasks for meaning making (Donovan & Bransford, 2005), connect old knowledge to new knowledge (Ball & Forzani, 2010; Vygotsky, 1980), and old experiences to new (Goldstone & Son, 2005). Even with the use of questions, the teachers were not observed using effective MTP of Facilitate meaningful mathematical discourse, and Elicit and use evidence of student thinking. Teachers were not observed using questioning to dig deeper in order to reach the MTP of facilitate meaningful mathematical discourse, and elicit and use evidence of student thinking. Hence, these two MTP were not observed during the study.

In the analysis of the data, the selected MTP of questioning always occurred with another effective MTP, verbal visual. The NCTM (2014) use and connect mathematical representations defines selected MTP as "engaging students to see connections among mathematical representation to deepen understanding of mathematical concepts and procedures for problem solving" (NCTM 2014, p.24). The code of verbal visual was created and used to capture when the teacher said or did something that referenced an action on the IWB. An example of verbal visual used by a teacher was an activity where the student had to find the slope of a line. The IWB had a template with the table, graph, and slope formula showing. De Vita et al. (2014) and Glover et al. (2005) contend the IWB is useful in supporting the teaching of multiple representations, such as slope of a line. The teacher worked out the problem, and then would discuss the problem with the class. The teacher would point to the graph, and say "so the y values represent the rise, and the x value represent the run." The teacher pointed to the corresponding table for the graph, picked values to use in the slope formula, and calculate the slope. The teacher would then go back to the graph and show the students how to find the slope graphically. The ability of the IWB to support movement from the verbal to the visual (Glover et al., 2005) allows the teacher the opportunity to present multiple representations of algebraic concepts NCTM (2014) to aid the teacher in utilizing high leverage practices characterized by Ball and Forzani (2010).

As mentioned above, the occurrence of the visual verbal was accompanied by the selected MTP of questioning. This does make sense for this to occur during a lesson since the teacher would ask a question, wait for student responses, and continue with another question or a visual verbal response. Figure 6 illustrates this occurrence.

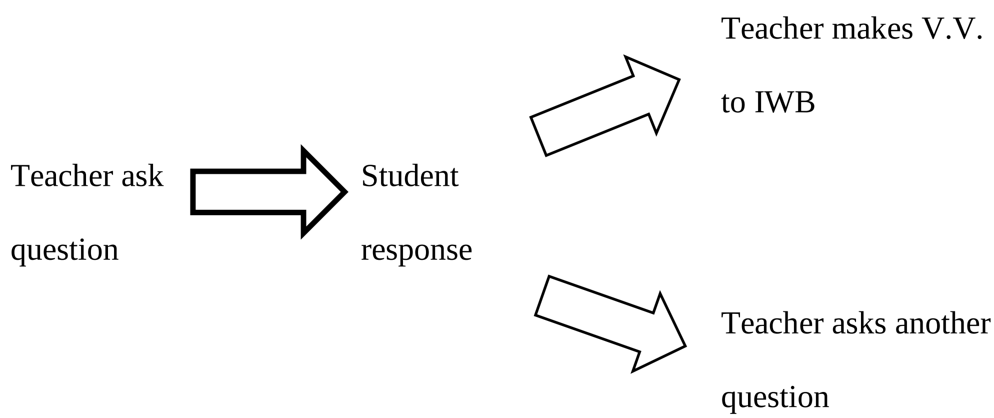

Figure 5.4 Diagram of teacher VV and Q with student

This co-occurrence of both the selected MTP Q and VV, was typical and when this happened the teacher used the IWB at the Interactive level most of the time, followed by the enhanced interactive level. The following illustrates an example of both selected MTP of Q and VV co-occurring.

Teacher: What happens when you divide with exponent? Q

Student: Silence

Teacher: What do you actually do with the exponent part? Q

Student: Subtract.

Teacher: So if we say like number two we've had $X^4Y^5Z^{-2}x^3Y^{-9}Z^5$. V.V.

The process of using questions while students are working problems allows opportunities for teacher insight to monitor student understanding, and according to Stein and Smith (2011), provides teachers with more control over student centered pedagogy. In conclusion, the selected MTP of questioning, and verbal visual were both observed individually and co-occurring during the observations of all teachers, and when they occurred, the teachers used the IWB at the Interactive level most of the time followed by the enhanced interactive level, and support didactic last. This finding agrees with teacher's self-reported interview data where the teachers indicated use of IWB at the interactive level most of the time, specifically working out problems on the IWB for whole class discussion. This would also explain the observations of iterations from the verbal visual and questioning between the teacher and class.

Key Conclusion 2: Observed IWB level of use. The second section of the conclusions discusses the observed IWB level of use (Support Didactic, Interactive, and Enhanced Interactive) that was observed during the study. Findings indicate teachers used the IWB at the interactive level the most, followed by the enhanced interactive level, and support didactic level, see table 44. The percentages that a teacher was at the interactive level was obtained by diving the time teacher taught at the interactive level divided by the total time of the lesson. Q and VV are frequency counts for the teacher. Reading table

5.1 for example, TAV1 means teacher A was the interactive level 29.74% of the time during the lesson with 31 occurrences of Q, and 37 occurrences of VV while teaching at the interactive level, and Teacher A was at the enhanced interactive level for 68.07% of the time during the lesson with 15 occurrences of Q and 27 occurrences of VV.

Table 5.1
Observed IWB level of use

Teacher	**Interactive**	**Questioning**	**Verbal Visual**	**Enhanced Interactive**	**Questioning**	**Verbal Visual**
TAV1	29.74%	31	37	68.07%	15	27
TAV2	95.64%	69	70	4.36%	0	0
TAV3	93.68%	71	75	6.32%	0	0
TBV1	88.37%	152	134	7.12%	9	5
TBV2	87.00%	71	36	0.00%	0	0
TBV3	82.72%	47	23	0.00%	0	0
TCV1	28.31%	48	41	11.04%	16	12
TCV2	75.83%	41	48	21.92%	6	5
TCV3	47.765	38	35	38.02%	7	16

**TAV1 stands for Teacher A Video , questioning and verbal visual are frequencies*

During the course of the study, typical teacher behaviors of IWB use at the support didactic were: use of predefined flip chart pages containing problems, notes, definitions, basically content presented for the student to copy down. These observations were corroborated by teacher interview responses stating that they used the IWB for presenting notes, and practice problems. These uses of the IWB are what Glover et al (2007) define as the support didactic level of IWB use. Teachers were observed using the IWB at the interactive level during the course of this study. Typical teacher behaviors observed were: changing the color of the ink, using the erase feature, highlighting, capturing screen shots, importing PDF's, flipping back and forth between pages. The observations are consistent with the literature of what constitutes the Interactive level of use. These include:

- Coloring, and highlighting important content, using the hide/reveal and drag and drop function (Türel & Demirli, 2010)
- Flipping back and forth between content (Levy, 2002; H. J. Smith et al., 2005)
- Use pictures for class discussion, peer-teaching, collaborative problem solving
- Observing different media-visual learners (Bell, 2002)
- Zoom in on content, good for visually impaired (L. Smith, 2008)
- Capturing screenshots
- Use of spotlight to reveal hidden part of screen (Beauchamp & Parkinson, 2005)

These observations were corroborated by teacher interview responses stating that they used the features of highlighting, erase, color change, flipping back and forth between flip charts, capturing screen shots, and importing PDF's. Glover et al. (2007) contends that when a teacher is aware of the affordances the IWB has to offer to their pedagogical practices, and uses them as an integral part of their teaching and conceptual understanding, their IWB is used at the highest level, and the enhanced interactive level.

Below are two examples of the many examples where the IWB was used at the enhanced interactive level. In the first example, Teacher A used the IWB at the enhanced interactive level when teacher A used a ball, which was thrown by students at the IWB, causing an equation to pop up. Students would solve the equation on their own. Incidentally, Teacher B during their interview stated they did this same activity on a different type of IWB a few years ago when Teacher B taught at another school district. This is interesting in that Teacher A had adapted Teacher B's activity to work with the current IWB, even though the current IWB Teacher A has is not capable of the same activity Teacher B used. Teacher A made the activity work through adapting. It is uncertain if Teacher A and Teacher B had collaborated about this particular lesson, but both teachers did say during their interviews they had no formal training, but were self-taught, and learned via peer collaboration. Beauchamp (2004) contends teachers play around with and explore ways the IWB can impact teaching and learning. In the ball example just mentioned, Teacher A was observed adapting a teaching activity in order to incorporate the IWB, even though the IWB did not have the capacity to support the activity on its own. The teacher had an understanding of what mathematics concept they wanted to teach, and realized the technological limitations of the IWB, yet made the mathematic activity take place. This teacher behavior of combining the teachers' technical skills and pedagogical vision is what Mishra and Koehler (2006) define as the TPACK model.

In conclusion, all of the videos indicated the teacher used the IWB at the interactive or enhanced interactive level, yet during the interviews, all teachers indicated they had no formal training. It seems reasonable to deduce teachers develop the capacity to adopt/adapt their technological knowledge when confronted with tools that impact their pedagogical practices.

Key Conclusion 3: Unexpected Observations. This next section of the conclusion will consist of results expected to observe during the study, followed by what actually happened during the study along with an explanation citing the literature. The expectation was teachers to use the IWB at the support didactic level most of the time, followed by the interactive level next, and Enhanced Interactive level the least amount of time. This assumption was based upon all three teachers' responses during the interview when asked if they had any formal training in how to use the IWB. Another expectation was for the teachers to have a good bit of formal training, over the course of their teaching careers. All three teachers said they had no formal training on how to use the IWB, but learned how to use the IWB by figuring it out themselves and networking with other teachers. Even with the lack of formal training, data obtained from the study indicate teachers used the IWB at the Interactive level, Enhanced Level, and support didactic level in that order, which is different from what was expected to find. A plausible explanation could be in the TPACK framework used for this study. Specifically, teachers technological pedagogical knowledge (TPK), which is knowledge of affordances technology can offer to teaching and learning (Mishra & Koehler, 2006). All three teachers indicated affordances (Gibson, 1977) the IWB could offer to their teaching, even though teachers indicated no formal training for the IWB. The teachers developed their technological knowledge over the course of them using the IWB, along with the realization of their IWB has an impact upon their teaching practices, which lead to an influence upon the Technological Pedagogical Content Knowledge. This was observed during the course of this study, and is consistent with what Niess et al. (2009) describe as the process of teachers integrating technology into their teaching practices by progressing through five stages, recognizing, accepting, adapting, exploring, and advancing.

Teacher A during a math lesson dealing with solving equations, illustrated the adapting stage identified by Niess (2009). Teacher A used the IWB not in a typical manner to teach the lesson, instead Teacher A called a student to the front of the board, gave them a ball to throw at the board, which displayed numbered colored bubbles. The ball would strike a bubble, causing it to pop, and reveal an equation for the class to solve. Teacher A called on a student to tell the class how they worked out the problem, and if correct, the student would be allowed to throw the ball at the board. This process continued for the remainder of the lesson. This example also illustrates Neiss's (2009) exploring level, where Teacher A actively integrated teaching and learning of mathematics. Teacher A utilized the IWB with a visual display of colorful bubbles, which was an aesthetic stimulus, to engage students, and prompt discussion for students learning to solve equations. Glover et al. (2005) defines this use by Teacher A as an example at the enhanced interactive level. Even though this was not expecting the above results, this example illustrates a teacher's progress, and how they adapted their pedagogical practices to help their students learn.

Similar to Teacher A, Teacher C used the IWB to demonstrate to students how to take notes. Teacher C imported a template called Cornell notes onto the board, and demonstrated how to take notes with the template during the product property of exponents lesson. The template contained a spaced for notes, a place for definitions, and a space to include examples. Teacher C wrote the notes on the IWB for students to copy, then had students come to the board to put their notes up. The class discussed what students put on the board, and made changes to improve the notes. Teacher C used screen capture software for this use of the IWB for students to reference later, which is what Niess et al. (2009) describe as the exploring stage. During an observation of Teacher B, students came to the IWB and worked out slope of a line with the slope formula, and using a Cartesian number template to graphically determine the slope of a line. The use of the IWB in this manner allowed the students and class to discuss working out the slope problem using multiple representations of slope, and also illustrates Niess (2009) stage of accepting the technology by the teacher.

So, how do the above conclusions inform the research question of how does the use of an IWB impact an algebra teacher's implementation of selected mathematics teaching practices? In summary, teachers develop and increase their TPACK, adapt their pedagogical practices of the IWB to the interactive and enhanced interactive level of use which occurred with the MTP's of Q and VV. The MTP's of Q and VV tended to co-occur.

Implications for Research

The implications section will address issues that change the understanding of the field of teaching and learning mathematics. The areas of theory, research, and practice will be the focus of the implications. Findings from this study are consistent with current theories in the field. Glover et al. (2005) identified support didactic, interactive, and enhanced interactive as levels teachers use the IWB, similarly Niess et al. (2009) identified five stages of development teachers progressed through using technology. Findings from the study are consistent with both of the theories. Teachers were observed using the IWB at the three levels Glover et al. (2005) identified, and teachers were observed progressing through the different levels identified by Niess et al. (2009). Interestingly, there were theories where findings from the study initially appeared to not align. All teachers in the study said they had no formal training using the IWB, yet used the IWB at high levels. This contrasts Beauchamp and Kennewell (2013) assertion teachers need professional learning to develop skills for using the IWB at a high level that can impact pedagogy, along with Türel and Johnson (2012) claim teachers need more training to develop instructional strategies of using the IWB. Cleary, the findings illustrate the importance of professional development opportunities which focus on developing teacher technical pedagogical knowledge as defined by Mishra and Koehler (2006). If teachers have a better understanding of how they develop their capacity to use technology, and the interaction with pedagogical practices and content knowledge, it might allow teachers to progress through the stages of Neiss et al (2009) in a more timely fashion.

The NCTM (2014) identified mathematics teaching practices to provide a framework to strengthen mathematics teaching and learning. Findings from this study are consistent with teaching practices the NCTM identified and include: the use and connect mathematical representations, implement tasks that promote reasoning and problem solving, establish mathematics goals to focus learning, propose purposeful questions, and support productive struggle. The use of these mathematics teaching practices was beneficial for this study in that it allowed for the identification of teacher content and pedagogical knowledge recognized by the NCTM for mathematics teaching and learning. Specifically, the use and connect mathematical representations, and propose purposeful question emerged from the data as mathematics teaching practices that tended to co-occur. These two findings fit in with prior research. Walkington and Wasserman (2013) contend enhanced visual affordances directly impacts the learning of algebra and Fuson et al. (2005) the use of multiple representations, which strengthen mathematics teaching and learning.

Findings from the study are consistent with the theoretical framework selected for investigating this study, TPACK. The TPACK model (Mishra & Koehler, 2006) lies at the intersection of three domains, technological knowledge, content knowledge, and pedagogical knowledge. Mishra and Koehler (2006) assert that teachers that use the IWB for lecture, presentation of notes, and videos are not changing teaching practices to fully incorporate the full capabilities of the IWB. Slay et al. (2008) also contend teachers need a shift in their teaching practices, which must take place within the TPACK domain. Findings from the study indicate teachers used the IWB at higher levels even though the teachers did not receive any formal training on how to use the IWB. De Vita et al. (2014) and Glover et al. (2005) say using the dynamic capabilities of IWB represents the paradigmatic pedagogical changes teachers must make to fully incorporate the technology. Again findings from this study are consistent with these pedagogical practices, by observed behaviors of teachers using the IWB.

Implications for Practice

This study's findings may be helpful to teachers, professional development specialists, principals/superintendents, and teacher training programs. Teachers can use information from the findings to inform instructional practices, lesson planning, and inform the amount and pacing of content that will be covered. For example, teachers can use the IWB as a poster session for students to work out problems and spur discussion about math problems. Principals/superintendents can use information developed from this study to help curriculum departments develop and adapt in-service professional development opportunities for teachers in the use of the IWB and MTP. For example, principals can observe teachers using the IWB, make notes about the level of use of IWB and MTP, and then offer teachers training to use the IWB at higher levels with MTP. Along a similar note, teacher training programs can use the information gained from this study to develop preservice teacher programs pertaining to the use of the IWB, MTP, and TPACK. For example, mentoring teachers can observe in service teachers teaching with the IWB, note their level of use, and offer training opportunities to increase their level of IWB use. Finally, teachers can use information from this study to help them gain an understanding of how to use the technology and the impact upon their teaching. For example, a teacher may develop their TPACK in a more efficient manner to allow them to use the IWB at a higher level of use and MTP.

Contributions to the Literature

This section includes findings from this study identified several areas which could add to the knowledge base, such as to identifying new variable(s), measurement, and research design. The co-occurrence of the selected MTP of use and connect mathematical representations, and pose purposeful questions, provides an area for investigation in the literature. This could lead to a better understanding of the co-occurrence. For instance, does the occurrence of questioning and verbal visual alone differ than when questioning and verbal visual occur together. Is the co-occurrence of questioning and verbal visual a new domain of a MTP not previously understood that could be identified and quantified as a new variable(s). Also, the identification of levels of different types of questions used by the teachers, such as structure questions, probing questions, and higher order questions is not new. Mason (2000) and Holster (2006) have provided frameworks for questioning in the mathematics classroom, and findings from this study could aid in the development of how to measure questions and pedagogical practices of teachers using questioning. For instance, a study could investigate the frequency of a teacher asking certain types of questions identified by Mason and Holster (2006) while counting the occurrences of MTP as used in this study. This study may have identified a process of how teachers progress from no/low technical knowledge to

TPACK without any formal training. Implications from the study can help provide structure for research in the field of teaching and learning mathematics, perhaps to better understand the co-occurrence of the selected MTP of purposeful questioning and use and connect mathematical representations. For instance, does the co-occurrence happen in certain math lessons and not in others? What are the circumstances where they occur and what circumstances do they not occur?

Future Research

An area of future research might focus on a different level of mathematical content areas such as Advanced Placement and honors level mathematics classes. The results from investigating these types of class might not be similar to those from this study, which focused upon an algebra classroom. The current study was conducted in a public secondary high school and future research at private schools, or alternative education sites might yield results different from those found in this study. The observation of hand gesturing while teachers were using the IWB might be an area future research can investigate for an impact upon selected MTP. Current research in hand gesturing is noted in the literature pertaining to Information and communication technology (Abrahamson, 2004; Miller & Glover, 2010), but the investigation of the intersection of IWB level of use and selected MTP might be an area for future research.

Another area for future research would be to develop computer software using artificial intelligence to automatically code videos of teacher behaviors while using the IWB. This information could be used in real time to inform IWB level of use, selected MTP, and pedagogical practices. This could add another path for future research to precisely and accurately measure the behavior of teacher use of IWB and selected mathematical practices. A natural extension of this study would be to identify and measure other independent and dependent variables, such as how to quantify teacher level of IWB use, how to quantify selected MTP, beyond mere frequency counts and duration as in this study.

Concluding Thoughts

So, how do the above conclusions inform the research question of how does the use of an IWB impact an algebra teacher's implementation of selected mathematics teaching practices? In summary, teachers develop the capacity to influence TPACK based upon their understanding the IWB offers to their pedagogical practices of the IWB. When teachers used the IWB at the interactive and enhanced interactive level of use, the most frequently co-occurring MTP were purposeful questioning and use and connect mathematical representations.

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APPENDIX A

TPACK FRAMEWORK

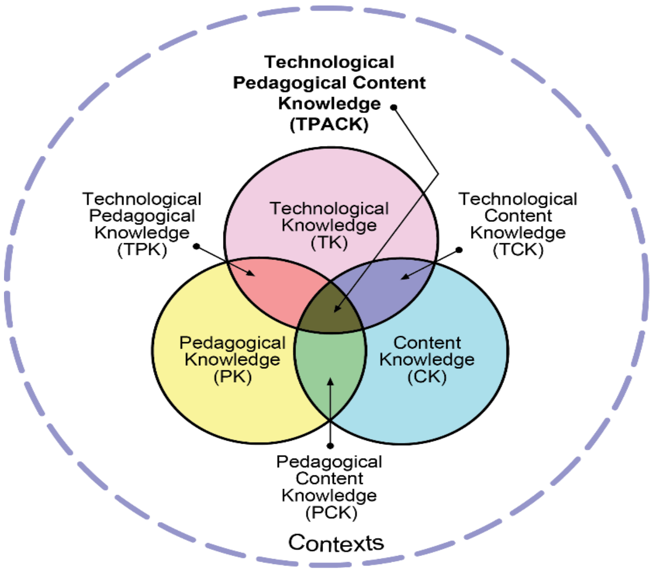

Figure A.1 Graphic Depiction of New Teacher Education Models. Image reproduced by permission of publisher, © 2012 by tpack.org.

APPENDIX B

INTERVIEW FOR TEACHER LEVEL OF IWB USE

Support Didactic

Teacher is at this level if she or he answer yes to both questions below, and no to any questions in either the interactive or enhanced interactive.

Do you use the IWB mainly for the visual support of the lesson? How?

You do not use the IWB for concept development? How?

Interactive

Teacher is at this level if he or she answers yes to any of the 3 questions below or no to any questions at the enhanced interactive

Do you have verbal stimuli in lessons you create with the IWB that challenge students to think? How?

Do you have visual stimuli in lessons you create with the IWB that challenge students to think? How?

Do you have aesthetic stimuli in lesson you create with the IWB that challenge students to think? How?

Enhanced Interactive

Teacher is at this level if he or she answers yes to all questions below. Teachers answering no to any will be placed at the interactive level.

Are you aware of features the IWB has to offer to your teaching? How?

Do you use the IWB as an integral part of your teaching? How?

Do you use the IWB as an integral part of your teaching to enhance conceptual understanding and cognitive development? How?

Do you use the verbal stimuli of the IWB to prompt discussions, explain processes, and develop hypothesis to facilitate student learning? How?

Do you use the visual stimuli of the IWB to prompt discussion, explain processes, and develop hypothesis to facilitate student learning? How?

Do you use the aesthetic stimuli of the IWB to prompt discussion, explain processes, and develop hypothesis to facilitate student learning? How?

Demographic questions

How long have you been teaching?

What is your highest degree?

What is your major?

How did you become certified?

Are you National Board Certified? How long? Recertified?

How long have you used the IWB?

What training have you had in the use of the IWB?

APPENDIX C

MATHEMATICS CLASSROOM OBSERVATION PROTOCOL FOR PRACTICES ($MCOP^2$)

Mathematics Classroom Observation Protocol for Practices: Descriptors Manual
The Mathematics Classroom Observation Protocol for Practices (MCOP2) is a K-16 mathematics classroom instrument designed to measure the degree of alignment of the mathematics classroom with the various standards set out by the corresponding national organization that focus on conceptual understanding in the mathematics classroom including:

• Common Core State Standards in Mathematics: Standards for Mathematical Practice **(National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010)**,

• Mathematical Association of America (MAA): CUPM Curriculum Guide **(Barker, et al., 2004)**,

• American Mathematical Association of Two-Year Colleges (AMATYC): "Crossroads" **(AMATYC, 1995)** and "Beyond Crossroads" **(AMATYC, 2006)**, and

• National Council of Teachers of Mathematics (NCTM): Process Standards **(NCTM, 2000)**.

Recommended Uses
The MCOP2 form is designed to measure the activities occurring in a mathematics classroom during a single lesson. However, if one desires to measure the overall activities of a class, the form should be used to measure at least three different class settings. **An important item to remember is that while all of the items in the observation protocol are desired qualities of a mathematics classroom, not all of them are expected to be observed during a single lesson. It is expected that this instrument be used in a formative manner on single observations. Summatively, 3-6 observations are ideal in evaluating classroom instruction.**
The MCOP2 form is not designed to be used during a single lesson or day to evaluate the teaching and learning atmosphere of the mathematics classroom.

When completing the MCOP2 form, it is essential that the descriptors outlined in this manual are followed to maintain the validity and reliability of the instrument.

How to Score

The MCOP² measures two distinct factors of Teacher Facilitation and Student Engagement through two subscales of 9 items each. (The MCOP² is not designed to get a single score of a classroom.)

The Teacher Facilitation subscale (Cronbach alpha of 0.850) measures the role of the teacher as the one who provides structure for the lesson and guides the problem solving process and classroom discourse. To calculate the score for the Teacher Facilitation subscale, one would add the scores for items 4, 6-11, 13, and 16.

The Student Engagement subscale (Cronbach alpha of 0.897) measures the role of the student in the classroom and their engagement in the learning process. To calculate the score for the Student Engagement subscale, one would add the scores for items 1-5 and 12-15.

Item	Student Engagement	Teacher Facilitation
1	X	
2	X	
3	X	
4	X	X
5	X	
6		X
7		X
8		X
9		X
10		X
11		X
12	X	
13	X	X
14	X	
15	X	
16		X

1) Students engaged in exploration/investigation/problem solving.

The role of exploration, investigation, and problem solving is central in teaching mathematics as a process. In order for students to develop a flexible use of mathematics, they must be allowed to engage in exploration, investigation, and/or problem solving activities which go beyond following procedures presented by the teacher. Furthermore, problem solving can be developed as a valuable skill in itself (Barker, et al., 2004) and a way of thinking (NCTM, 1989), rather than just as the means to an end of finding the correct answer. Student exploration may also promote a stance of mathematics as a discipline that can be explored, reasoned about, connected to other subjects, and one that 'makes sense' (Barker, et al., 2004).

> Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

If students are following a procedure established by the teacher, then it does not count as exploration/investigation/problem solving. Instead, students should be determining their own solution pathway without necessarily knowing that the path will lead to the desired result.

Score	Description
3	Students regularly engaged in exploration, investigation, or problem solving. Over the course of the lesson, the majority of the students engaged in exploration/investigation/problem solving.
2	Students sometimes engaged in exploration, investigation, or problem solving. Several students engaged in problem solving, but not the majority of the class.
1	Students seldom engaged in exploration, investigation, or problem solving. This tended to be limited to one or a few students engaged in problem solving while other students watched but did not actively participate.
0	Students did not engage in exploration, investigation, or problem solving. There were either no instances of investigation or problem solving, or the instances were carried out by the teacher without active participation by any students.

2) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent concepts.

In mathematics instruction it is common for the teacher to use various representations (models, drawings, graphs, concrete materials, manipulatives, graphing calculators, compass & protractor, i.e. tools for the mathematics classroom) to focus students' thinking on and develop their conceptions of a mathematical concept. It is also important for students to interact with and develop representations of mathematical concepts and not merely observe the teacher presenting such representations. Thus, this item is concerned with whether the students use representations to represent mathematical concepts. The representations can be student generated (a drawing or a graph) or provided by the teacher (manipulatives or a table), but it is the students that must then use the representation. Just because there is a representation in a lesson, if it is only used by the teacher while students watch (such as a graph on a PowerPoint slide), it is not considered to be used by students unless the students manipulate and interact with the representation.

Students' notes can count as a type of representation if the students themselves offer some sort of input. For instance, if a student corrects a teacher's mistake in a problem he or she is copying down then the notes are actually being manipulated by a student and should therefore count as a type of representation.

Score	Description
3	The students manipulated or generated two or more representations to represent the same concept, and the connections across the various representations, relationships of the representations to the underlying concept, and applicability or the efficiency of the representations were explicitly discussed by the teacher or students, as appropriate.
2	The students manipulated or generated two or more representations to represent the same concept, but the connections across the various representations, relationships of the representations to the underlying concept, and applicability or the efficiency of the representations were **not** explicitly discussed by the teacher or students.
1	The students manipulated or generated one representation of a concept.
0	There were either no representations included in the lesson, or representations were included but were exclusively manipulated and used by the teacher. If the students only watched the teacher manipulate the representation and did not interact with a representation themselves, it should be scored a 0.

3) Students were engaged in mathematical activities.

This item is concerned with the extent of student engagement in activities that are mathematical. Students are considered to be engaged in a mathematical activity when they are investigating, problem solving, reasoning, modeling, calculating, or justifying (each of these could be written or verbal).

Note "most of the students" in an undergraduate mathematics classroom is accepted here to mean more than one-third of the students in the classroom were engaged in mathematical activity, while in a K-12 mathematics classroom it means more than one-half.

It is important to note that one should only focus on what actually happens—not what the teacher assigns watching for students who are off-task.

Score	Description
3	Most of the students spend two-thirds or more of the lesson engaged in mathematical activity at the appropriate level for the class. It does not matter if it is one prolonged activity or several shorter activities. (Note that listening and taking notes does not qualify as a mathematical activity unless the students are filling in the notes and interacting with the lesson mathematically.)
2	Most of the students spend more than one-quarter but less than two-thirds of the lesson engaged in appropriate level mathematical activity. It does not matter if it is one prolonged activity or several shorter activities.
1	Most of the students spend less than one-quarter of the lesson engaged in appropriate level mathematical activity. There is at least one instance of students' mathematical engagement.
0	Most of the students are not engaged in appropriate level mathematical activity. This could be because they are never asked to engage in any activity and spend the lesson listening to the teacher and/or copying notes, or it could be because the activity they are engaged in is not mathematical – such as a coloring activity.

4) Students critically assessed mathematical strategies.

In order for students to flexibly use mathematical strategies, they must develop ways to consider the appropriateness of a strategy for a given problem, task, or situation. This is because not all strategies will work on all problems, and furthermore the efficiency of the strategy for the given context needs to be considered. For students to make such distinctions it is important that they have opportunities to assess mathematical strategies so that they learn to reason not only about content but also about process. This item is concerned with *students* critically assessing strategies, which is more than listening to the teacher critically assessing strategies or asking peers how they solved a task. Examples of critical assessment include students offering a more efficient strategy, asking "why" a strategy was used, comparing/contrasting multiple strategies, discussing the generalizability of a strategy, or discussing the efficiency of different ways of solving a problem (e.g. the selection appropriate tools if needed).

To score high on this item it is the students who must be engaged in the critical assessment, not only the teacher.

Score	Description
3	More than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.
2	At least two but less than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.
1	An individual student critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher. The critical assessment was limited to one student.
0	Students did not critically assess mathematical strategies. This could happen for one of three reasons: 1) No strategies were used during the lesson; 2) Strategies were used but were not discussed critically. For example, the strategy may have been discussed in terms of how it was used on the specific problem, but its use was not discussed more generally; 3) Strategies were discussed critically by the teacher but this amounted to the teacher telling the students about the strategy(ies), and students did not actively participate.

5) Students persevered in problem solving.

One of the *Standards for Mathematical Practice* (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) is that students will persevere in problem solving. Student perseverance in problem solving is also addressed in the Mathematical Association of America's Committee on the Undergraduate Program in Mathematics Curriculum Guide (Barker, et al., 2004):

> Every course should incorporate activities that will help all students…approach problem solving with a willingness to try multiple approaches, persist in the face of difficulties, assess the correctness of solutions, explore examples, pose questions, and devise and test conjectures.

Perseverance is more than just completion or compliance for an assignment. It should involve students overcoming a road block in the problem solving process.

Score	Description
3	Students exhibited a strong amount of perseverance in problem solving. The majority of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), the majority of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem.
2	Students exhibited some perseverance in problem solving. Half of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), half of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem.
1	Students exhibited minimal perseverance in problem solving. At least one student but less than half of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), at least one student but less than half of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem. There must be a road block to score above a 0.
0	Students did not persevere in problem solving. This could be because there was no student problem solving in the lesson, or because when presented with a problem solving situation no students persevered. That is to say, all students either could not figure out how to get started on a problem, or when they confronted an obstacle in their strategy they stopped working.

6) **The lesson involved fundamental concepts of the subject to promote relational/conceptual understanding.**

Relational/conceptual understanding is “knowing both what to do and why” (Skemp, 1976). This is in contrast to a procedural understanding as being able to compute certain mathematical activities, but not understanding how the computation works or when one would need to use such a computation and what the answer would mean.

According to the NCTM (2006), certain topics are core to the mathematics learned at each grade level and can form the backbone of the K-8 curriculum. The NCTM extended this concept to the high school level with an emphasis on using these fundamental concepts to make sense of mathematics and deepen students’ relational and conceptual understanding (Martin, et al., 2009). Similar to the NCTM’s guidelines for middle school and high school mathematics lessons, at the undergraduate level the Mathematical Association of America has recommendations in the Committee on the Undergraduate Program in Mathematics Curriculum Guide (Barker, et al., 2004) for departments, programs, and all courses to promote relational/conceptual understanding for both mathematics majors and non-mathematics majors.

Score	Description
3	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, and the teacher/lesson uses these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.
2	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, but the teacher/lesson misses several opportunities to use these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.
1	The lesson mentions some fundamental concepts of mathematics, but does not use these concepts to develop the relational/conceptual understanding of the students. For example, in a lesson on the slope of the line, the teacher mentions that it is related to ratios, but does not help the students to understand how it is related and how that can help them to better understand the concept of slope.
0	The lesson consists of several mathematical problems with no guidance to make connections with any of the fundamental mathematical concepts. This usually occurs with a teacher focusing on procedure of solving certain types of problems without the students understanding the “why” behind the procedures.

7) The lesson promoted modeling with mathematics.

Following the "Standards for Mathematical Practice" from the Common Core State Standards (2010) and the recommendations from the MAA's CUPM Curriculum Guide (Barker, et al., 2004), this item describes lessons that help students to "apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another" (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

In an undergraduate classroom, a lesson that promotes modeling might use "radiocarbon dating to illustrate how an initial value problem (IVP) can model a real world situation, and the solution of the IVP then yields obviously useful and interesting results" or "a simple system of differential equations to predict the cyclical population swings in a predator-prey relationship" or even "how modular arithmetic is used in cryptography and the transmission of encoded information" (Barker, et al., 2004).

Score	Description
3	Modeling (using a mathematical model to describe a real-world situation) is an integral component of the lesson with students engaged in the modeling cycle (as described in the Common Core State Standards).
2	Modeling is a major component, but the modeling has been turned into a procedure (i.e. a group of word problems that all follow the same form and the teacher has guided the students to find the key pieces of information and how to plug them into a procedure.); **or** modeling is not a major component, but the students engage in a modeling activity that fits within the corresponding standard of mathematical practice.
1	The teacher describes some type of mathematical model to describe real-world situations, but the students do not engage in activities related to using mathematical models.
0	The lesson does not include any modeling with mathematics.

8) The lesson provided opportunities to examine mathematical structure. (Symbolic notation, patterns, generalizations, conjectures, etc.)

Following some of the "Standards for Mathematical Practice" (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) and the recommendations in the MAA's CUPM Curriculum Guide (Barker, et al., 2004), lessons should include opportunities for students to contextualize and/or decontextualize in the process of solving quantitative problems, explore and make use of mathematical structure, or to use repeated reasoning to generalize certain categories of problems and their solutions.

Score	Description
3	The students have a sufficient amount of time and opportunity to look for and make use of mathematical structure or patterns.
2	Students are given some time to examine mathematical structure, but are not allowed adequate time or are given too much scaffolding so that they cannot fully understand the generalization.
1	Students are shown generalizations involving mathematical structure, but have little opportunity to discover these generalizations themselves or adequate time to understand the generalization.
0	Students are given no opportunities to explore or understand the mathematical structure of a situation.

9) The lesson included tasks that have multiple paths to a solution or multiple solutions.

As part of having students "make sense of problems and persevere in solving them" (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), students must be encouraged to look for multiple methods of solving a problem and to deal with problems that have multiple solutions based upon various assumptions. Additionally, selected tasks with multiple paths to a solution or multiple solutions can increase the cognitive demand of the task for all students through the interaction of the teacher to ask questions of each student at their ability level (Stein & Smith, 1998). This flexibility, "switching (smoothly) between different strategies," and adaptivity, "selecting the most appropriate strategy" (Verschaffel, Luwel, Torbeyns, & Van Dooren, 2009) enables students to solve problems for which a solution path is not obvious.

Score	Description
3	A lesson which includes several tasks throughout; or a single task that takes up a large portion of the lesson; with multiple solutions and/or multiple paths to a solution and which increases the cognitive level of the task for different students.
2	Multiple solutions and/or multiple paths to a solution are a significant part of the lesson, but are not the primary focus, or are not explicitly encouraged; **or** more than one task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.
1	Multiple solutions and/or multiple paths minimally occur, and are not explicitly encouraged; **or** a single task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.
0	A lesson which focuses on a single procedure to solve certain types of problems and/or strongly discourages students from trying different techniques.

10) The lesson promoted precision of mathematical language.

This item follows the Standard of Mathematical Practice to "attend to precision". As such, "Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem" (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

This item also follows the MAA's CUPM Curriculum Guide recommendation to "develop mathematical thinking and communication skills" which states: "Students should read mathematics with understanding and communicate mathematical ideas with clarity and coherence through writing and speaking" (Barker, et al., 2004).

Whether the communication is verbal or written and originating in the teacher or a student, using precise mathematical language is important. While the teacher cannot control the language used by students, there should be evidence of expectations of the teacher upon the students related to communicating with precise mathematical language. For example, if the lesson is primarily students solving problems, a culture of precision of language should come through in how the students are communicating with one another, both verbal and written.

Score	Description
3	The teacher "attends to precision" in regards to communication during the lesson. The students also "attend to precision" in communication, or the teacher guides students to modify or adapt non-precise communication to improve precision.
2	The teachers "attends to precision" in all communication during the lesson, but the students are not always required to also do so.
1	The teacher makes a few incorrect statements or is sloppy about mathematical language, but generally uses correct mathematical terms.
0	The teacher makes repeated incorrect statements or incorrect names for mathematical objects instead of their accepted mathematical names.

11) The teacher's talk encouraged student thinking.

This item assesses how well the teacher's talk promotes a number of the mathematical practices. Specifically, the practices requiring students to be able to think, reason, argue, and critique during the study of mathematical concepts (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). Teachers can greatly impact the level of student thinking and discussion simply by what questions are asked of students. In line with Stein, et al. (2009), the cognitive task level should be maintained at a high level, i.e. procedures with connections and doing mathematics, while questions which are over-scaffolded, rhetorical, or cursory to the level of the students, would score a 1 or a 0.

Specifically about the teacher's talk, this item is referring to the content of the question or statements put forth in the classroom for students to reason and/or discuss. A well planned lesson may contain rich tasks for students to explore or problems to solve, but if the teacher's talk drops or removes student reasoning and problem solving, it has removed or reduced student thinking.

Score	**Description**
3	The teacher's talk focused on **high levels** of mathematical thinking. The teacher may ask lower level questions within the lesson, but this is not the focus of the practice. There are three possibilities for high levels of thinking: analysis, synthesis, and evaluation. ***Analysis:*** examines/ interprets the pattern, order or relationship of the mathematics; parts of the form of thinking. **Synthesis**: requires original, creative thinking. **Evaluation**: makes a judgment of good or bad, right or wrong, according to the standards he/she values.
2	The teacher's talk focused on **mid-levels** of mathematical thinking. **Interpretation**: discovers relationships among facts, generalizations, definitions, values and skills. **Application**: requires identification and selection and use of appropriate generalizations and skills
1	Teacher talk consists of **"lower order"** knowledge based questions and responses focusing on recall of facts. **Memory**: recalls or memorizes information. **Translation**: changes information into a different symbolic form or situation.
0	Any questions/ responses of the teacher related to mathematical ideas were rhetorical in that there was no expectation of a response from the students.

12) There were a high proportion of students talking related to mathematics.

The focus of this descriptor is on the proportion of students talking (frequency). The Standards for Mathematical Practice (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) encourages students to be active in making conjectures, exploring the truth of those conjectures, and responding to the conjectures and reasoning of others. In a classroom dominated by only a few students, classroom discourse may appear to be high, but all students must be engaged.

Score	Description
3	More than three quarters of the students were talking related to the mathematics of the lesson at some point during the lesson.
2	More than half, but less than three quarters of the students were talking related to the mathematics of the lesson at some point during the lesson.
1	Less than half of the students were talking related to the mathematics of the lesson.
0	No students talked related to the mathematics of the lesson.

13) There was a climate of respect for what others had to say.

This item adheres to the expectation provided in the third Standard for Mathematical Practice, "Construct viable arguments and critique the reasoning of others." Given that practice, students are expected to communicate with each other as part of an effective classroom community. Effective communication means that students will listen, question, and critique; this is part of the discourse expected in a mathematics classroom (Sherin, Mendez, & Louis, 2004). This item also encompasses the literature on equity and mathematics in that all students have valuable ideas, strategies, and thinking to share within the mathematics classroom (Boaler, 2006). Equitable spaces include the interactions of students within a mathematical community that increase participation and engagement of all students and work to remove potential barriers (Diversity in Mathematics Education Center for Learning and Teaching, 2007; Gutierrez, 2007; Hiebert & Grouws, 2007; NCTM, 2000; Sherin, Mendez, & Louis, 2004; Yackel & Cobb, 1996). This means creating a climate of respect.

Score	Description
3	**Many** students are sharing, questioning, and commenting during the lesson, including their struggles. Students are also listening (active), clarifying, and recognizing the ideas of others.
2	The environment is such that **some** students are sharing, questioning, and commenting during the lesson, including their struggles. Most students listen.
1	Only a **few** share as called on by the teacher. The climate supports those who understand or who behave appropriately. **Or** Some students are sharing, questioning, or commenting during the lesson, but most students are actively listening to the communication.
0	No students shared ideas.

14) In general, the teacher provided wait-time.

The appropriate wait time must align with the question/task. In the elementary grades, a teacher may ask students to explain a situation that represents the expression 24*(1/2)*3. In middle school, the teacher may ask students to describe why the slope is positive. High school teachers may ask students to explain how linear and exponential functions are similar and different. In each instance, these questions/tasks are not simple yes/no answer and require wait time to provide an answer with meaning and understanding.

Simple Yes/No questions could be asked, but must be accompanied by an explanation. Simple skills or procedural problems should require explanations with the computation and/or procedures. If the class is dominated by rhetorical questions, a score of 0 or 1 is warranted. Even if rhetorical questions are asked, it is possible to score a 2 or 3 if there are questions asked sometimes or frequently that require students to reason, make sense, and articulate thoughtful responses.

Score	Description
3	The teacher **frequently** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.
2	The teacher **sometimes** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.
1	The teacher **rarely** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.
0	The teacher **never** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.

15) Students were involved in the communication of their ideas to others (peer-to-peer).

Both the National Council of Teachers of Mathematics and The Eight Standards for Mathematical Practices, expect teachers to create a mathematical community that includes dialogue around the mathematics content and learning. Students are expected to talk and participate in the discourse of the classroom (Manouchehri & St John, 2006). This item highlights the need for all students to be active participants in the classroom dialogue. Without teacher support and expectations, the classroom discourse can be monopolized or biased against certain populations (Mercer & Wegerif, 1999; Mercer, Wegerif, & Dawes, 1999; Rojas-Drummond & Mercer, 2003; Rojas-Drummond & Zapata, 2004).

This descriptor focuses on the amount of time students spend in communication with their peers at any level, including pairs, groups, informal settings, or whole class settings.

Score	Description
3	**Considerable** time **(more than half)** was spent with peer to peer dialog (pairs, groups, whole class) related to the communication of ideas, strategies and solution.
2	**Some** class time **(less than half, but more than just a few minutes)** was devoted to peer to peer (pairs, groups, whole class) conversations related to the mathematics.
1	The lesson was primarily teacher directed and little opportunities were available for peer to peer (pairs, groups, whole class) conversations. A few instances developed where this occurred during the lesson but only lasted less than 5 minutes.
0	No peer to peer (pairs, groups, whole class) conversations occurred during the lesson.

16) The teacher uses student questions/comments to enhance conceptual mathematical understanding.

Driscoll (1999; 2007) and Reys, et al. (2009) discuss how teacher questioning can build on student thinking to foster deeper mathematical thinking. In the elementary grades, students can make "over generalized" statements that have a correct nature about them. This is a teachable moment to use. A teacher can ask a question that has the student(s) reexamine their thoughts that would help simplify the over generalizing statement into precise understanding. Reys, et al. (2009) present a simple example, "Student: So every even number is composite. Teacher: Every even number? <Pause with wait time> What about 2?" The teacher's question stimulates further thought by the student. In secondary grades, Driscoll (1999) indicates that well-timed questions to students should help them shift or expand their thinking, or at least have students thinking about what is important to pay attention to during a lesson. When students are examining expressions, a teacher can ask questions to facilitate mathematical flexibility (Heinze, Star, & Verschaffel, 2009). For example, "What other ways can you write that expression to bring out the hidden meaning? How can you write the expression in terms of the important things you care about?"

Score	Description
3	The teacher **frequently** uses student questions/ comments to coach students, to facilitate conceptual understanding, and boost the conversation. The teacher sequences the student responses that will be displayed in an intentional order, and/or connects different students' responses to key mathematical ideas.
2	The teacher **sometimes** uses student questions/ comments to enhance conceptual understanding.
1	The teacher **rarely** uses student questions/ comments to enhance conceptual mathematical understanding. The focus is more on procedural knowledge of the task verses conceptual knowledge of the content.
0	The teacher **never** uses student questions/ comments to enhance conceptual mathematical understanding.

APPENDIX D

EXEL DATA ORGANIZATION SHEET

Teacher	IWB level of use from interview	MCOP[2]	Student engagement	Teacher Facilitation	Years teaching	Years' experience with IWB	Training with IWB	Amount of Training IWB (hours)	How became certified	NBCT
Teacher A	Interactive and enhanced interactive	Video1	23	15	10	5	no	0	Traditional	no
		Video 2	18	12						
		Video 3	16	17						
Teacher B	Interactive and enhanced interactive	Video1	19	17	15	10	no	0	Alternative	no
		Video 2	15	15						
		Video 3	14	17						

Teacher C	Interactive and enhanced interactive	Video1	18	17	20	8	no	0	Traditional	yes
		Video 2	16	14						
		Video 3	22	19						

*Traditional means certified through a college pre-service program.

APPENDIX E

EXCEL TABLE FOR VIDEO ANALYSIS

Turel level of IWB use	Features used with IWB	Frequency	Time
Support Didactic	Presentation mode only		
Interactive	Highlighter		
	Hide/Revel		
	Cut/Paste		
Enhanced Interactive	Enlarge/Shrink		
	Java Script apps		
	Computer software		

APPENDIX F

IRB APPROVAL

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH

DECLARATION of NOT RESEARCH

James Hartman

College of Education

Department of Instruction & Teacher Education

Wardlaw

Columbia, SC 29208

Re: **Pro00072798**

Dear Mr. Hartman:

This is to certify that research study entitled "***How does the use of an Interactive White Board impact an algebra teacher's implementation of effective mathematics teaching practices?***" was reviewed on **10/27/2017**, by the Office of Research Compliance, which is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). The Office of Research Compliance, on behalf of the Institutional Review Board, has determined that the referenced research study is not subject to the Protection of Human Subject Regulations in accordance with the Code of Federal Regulations 45 CFR 46 et. seq.

No further oversight by the USC IRB is required. However, the investigator should inform the Office of Research Compliance prior to making any substantive changes in the research methods, as this may alter the status of the project and require another review.

If you have questions, contact Arlene McWhorter at arlenem@sc.edu or (803) 777-7095.

Sincerely,

Lisa M. Johnson
ORC Assistant
Director and
IRB Manager