FACTORS THAT HAVE AN EFFECT ON STUDENTS' SCORES ON THE FLORIDA ALGEBRA 1 END-OF-COURSE ASSESSMENT IN ALGEBRA 1 CLASSROOMS USING INTERACTIVE WHITEBOARD TOOLS

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To my mom

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LIST OF ABBREVIATIONS

FRL	Free and Reduced Lunch
ISTE	International Society for Technology Education
IWTs	Interactive Whiteboard Tools
NCTM	National Council of Teachers in Mathematics
NETP	National Educational Technology Plan
OECD	Organization for Economic Cooperation and Development
PISA	Programme for International Student Assessment
SES	Socio-economic Status
STEM	Science, Technology, Engineering and Math

Abstract of Dissertation Presented to the Graduate School
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By

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August 2012

Chair: Kara Dawson
Cochair: Albert Ritzhaupt
Major: Curriculum and Instruction

This study examined the factors that have an effect on student scores on the Florida End-of-Course (EOC) Assessment in four secondary Algebra 1 classrooms using interactive whiteboard tools (IWTs). Four teachers and 335 students were observed in one public suburban school in central Florida during the second half of the spring term. Hierarchical linear modeling was used since the data existed at multiple levels. Student-level data, which included gender, race/ethnicity, and socioeconomic status (SES), were collected via the district and state's data warehouse. Teacher-level data were collected via observations using an observation rubric to determine teachers' levels of interactivity using IWTs, and teacher questionnaires were used to collect teachers' characteristics, which included levels of education, years of teaching experience, and length of time using IWTs. Results indicated that IWTs have a positive effect on student achievement as teachers progress in their levels of interactivity using IWTs.

CHAPTER 1
INTRODUCTION

> We're here for a simple reason: Everybody in this room understands that our nation's success depends on strengthening America's role as the world's engine of discovery and innovation.
>
> —President Obama (The White House, 2010)

Currently, the United States (U.S.) is in the midst of an educational reform targeting underperforming schools, districts, and states. As such, the U.S. is providing assistance through avenues such as the American Recovery and Reinvestment Act of 2009 (GovTrack, 2012) and incentives such as the Race to the Top Grant (Florida Department of Education [FLDOE], 2012a) to help make American students more competitive in the global landscape. In particular, emphasis is being given to science and mathematics as a result of national and international assessments (Programme for International Student Assessment [PISA]; National Assessment of Educational Progress [NAEP], and Trends in International Mathematics and Science Study [TIMSS]) suggesting that U.S. students are performing at an average to below-average rate compared to their peers in other countries (Fleischman, Hopstock, Pelczar, & Shelley, 2010; Gonzales et al., 2008; National Center for Education Statistics [NCES], 2009).

For example, a recent survey conducted by the Organisation for Economic Co-operation and Development's (OECD, 2009) PISA assesses how well "students near the end of compulsory education [i.e., 15-year-olds] have acquired some of the knowledge and skills that are essential for full participation in society" (Fleischman et al., 2010). PISA looks at reading, science, and mathematics literacy in terms of mastery of the curriculum and how well students are able to connect these concepts to the knowledge and skills needed in adult life. As such, PISA helps paint a picture of how well students are able to evaluate and apply to real-world contexts the skills learned during their compulsory school years. Data from the 2009 PISA cycle show that the U.S. is significantly below (487) the OECD average (496) for mathematics literacy (Fleischman et al., 2010).

Data from the PISA 2009, TIMSS 2007, and NAEP 2009 studies suggest that U.S. students are underperforming in mathematics, specifically in higher order skills and the application of knowledge to real-world contexts (NCES, 2009; OECD, 2009; TIMSS, 2007). It is important to note that even though these international assessments suggest U.S. students perform at an average to below-average rate compared to other countries, several critiques have raised the validity and reliability of these comparisons (Bonnet, 2002; Goldstein, 2004; Nash, 2003; Prais, 2003, 2004; Romainville, 2002). Most notably, assessments like PISA only cover a small portion of the education curriculum and might not capture the true picture of a country's school system (Dohn, 2007; Grisay & Monseur, 2007). Also, PISA might not fully measure a student's real-life experiences. Fensham (2009) suggested that more scrutiny is required in terms of the test items and the realities around data collection. In contrast, several critics (Mansell, 2007) suggested using data from the TIMSS assessment as a more accurate measure of a country's performance since they more closely assess pure curricular knowledge (i.e., the problems could be seen as more traditional). As such, looking at data from the PISA and TIMSS assessments and from the NAEP can help paint a more precise picture of the strengths and weaknesses U.S. students face in mathematics education.

In 2005, 15 of America's most prominent business organizations joined together to advocate for renewed attention to America's competitiveness and capacity to innovate.

The business organizations formed Tapping America's Potential (TAP, 2008) as a way to bring awareness to their

> deep concern about the ability of the United States to sustain its scientific and technological leadership in a world where newly energized foreign competitors are investing in the capacity for innovation—the key driver of productivity and economic growth in advanced economies (p. 2).

As a result of stagnant national and international assessment scores, specifically for math and science, and pressure from private industry to produce a workforce with a stronger critical-thinking and problem-solving skillset, the federal government has initiated and supported several programs, namely the Science, Technology, Engineering, and Mathematics (STEM) Initiative, a revamped National Education Technology Plan (NETP, 2010), and organizations like the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) with the state-led effort of Common Core State Standards.

These organizations and initiatives have made technology a key focus for supplementing change. As a result, technology has been at the forefront of how new and existing pedagogies and strategies can be augmented to include technology-rich content. In order to help educators think more broadly about the role of education technology, the Partnership for 21st Century Skills (2011) was conceived to combine a focus on outcomes (i.e., blending of specific skills, content knowledge, and literacies) and support systems that help give teachers and students a way to couple instruction and learning with effective technology integration.

Statement of the Problem

Mathematics education has been a key driver in education for many decades, and with the more recent focus on STEM initiatives, it has become vital in the development of the 21st century skills needed in the global workforce. More specifically, the topic of Algebra I is generally regarded as the gatekeeper topic that provides a reasonable indicator of student achievement in higher level mathematics (McCoy, 2005; Spielhagen, 2006; Wagner & Kieran, 1989). As the need to help students become more competitive in the global marketplace increases, mathematics instruction shifts in terms of how mathematics is learned and understood and how research-based strategies lead to increased student achievement. In order to help support this shift, technology has become an integral part of mathematics instruction. Technologies such as dynamic math software (e.g., Geometer's Sketchpad® and Fluidmath®), simulations (e.g., ExploreLearning Gizmos®), and IWT technologies (e.g., interactive whiteboard [IWB], learner response system [LRS], and lesson development software) have become commonplace in many mathematics classrooms. Although technology has the potential of enhancing mathematics instruction, this shift has been slow and gradual with schools. This is due to the cost of the technology, which prevents schools from accessing it, and the lack of professional development opportunities for teachers on how to use the technology—this is a barrier since teachers are less likely to be comfortable with a technology they have not consistently used. However, in a recent national survey by Grunwald Associates (2010) on technology and education, teachers cited IWTs as valuable digital resources because of their ease of use and potential to enhance content in many different ways. IWTs are defined as the combination of tools that include the IWB, LRS, and lesson development software.

Research on IWTs suggests that learning can become more interactive and engaging because IWTs provide stimuli that allow for prompt discussions, explain hypothetical processes, and help to differentiate instruction (Davis & Simmt, 2006; Davison & Pratt, 2003; Miller & Glover, 2011). IWTs also allow for greater forms of interactivity that permit increased opportunities for active learning and increased motivation to learn by providing multiple representations of content to meet the needs of a wider range of students (Glover, Miller, Averis, & Door, 2005; Jones & Tanner, 2007; Kent & Wynne, 2006; Smith, Hardman, & Higgins, 2006).

According to Swan (2005), there are specific strategies that can improve and facilitate the learning of mathematics. He argues that mathematics teaching can be most effective when it

- builds on previous knowledge,
- uses higher order questions and exposes misconceptions students might have,
- uses group work and teacher-student/student-student discourse,
- uses rich collaborative tasks,
- creates connections between topics and the real world, and
- uses technology to supplement instruction in meaningful ways.

Swan suggests that appropriate activities should include evaluating mathematical statements, creating problems and analyzing possible solutions, reasoning, and classifying and interpreting multiple representations. These strategies can be coupled with Miller and Glover's (2011) suggestions for successfully integrating IWTs with key pedagogical features, which include planning for cognitive development, providing clear and visual representation of concepts, using progression, illustrating concepts in different ways, sequencing, offering immediate feedback, practicing recall to strengthen learning, and planning activities that encourage an active thinking approach.

Purpose of the Study

The purpose of this study was to determine which factors had an effect on student scores on the Florida Algebra 1 End-of-Course (EOC) Assessment in four secondary Algebra 1 classrooms using IWTs. The study used seven independent variables: (1) student gender; (2) student race/ethnicity; (3) student socioeconomic status (SES); (4) teachers' length of time using IWTs; (5) teachers' levels of interaction using IWTs (i.e., supported didactic, interactive, or enhanced interactive); (6) teachers' years of teaching experience, and (7) teachers' education levels. There was one dependent variable: the Florida Algebra 1 EOC Assessment. The basis of this study was founded on the belief that IWTs have the potential of increasing student achievement in mathematics.

Research on IWTs in mathematics revealed that learning could be enhanced because of the tools' abilities to model abstract ideas more concretely and provide opportunities for immediate feedback to allow for concepts to be illustrated in different ways using multiple representations (Buckley, 2000; Glover, Miller, Averis, & Door, 2007; Jones & Tanner, 2007; Miller & Glover, 2004; Robison, 2000). The unique affordances of IWTs parallel many of the previously noted strategies proposed by Swan (2005); however, despite the potential of IWTs to complement effective mathematics strategies, research on how this can be achieved is scarce. This study adds to the growing body of research on how IWTs can help supplement mathematics instruction by asking the question, "What factors influence students' scores on the Florida Algebra 1 EOC Assessment in four secondary math classrooms using IWTs?"

Significance of the Study

As noted earlier, U.S. students lag behind in mathematics compared to their peers in other developed countries. Technology integration has been identified as a way to enhance mathematics education and instruction (National Council of Teachers of Mathematics [NCTM], 2000; NETP, 2010). Foltos (2002) stated that researchers have found it difficult to isolate technology as a variable in good instruction, but with the right circumstances, technology can play a significant role in enhancing student achievement.

IWTs have had a profound effect in education (Cuthell, 2004). According to Bryant and Hunton (2000), of the many tools available to teachers, IWTs may have the greatest potential for meeting the needs of students with diverse learning needs. Moreover, in the national survey conducted by Grunwald Associates (2010), teachers reported that using a variety of technology devices and Web-based systems helped them do their jobs better and helped them engage students in learning. Teachers cited IWTs as the most valuable digital resource for a variety of reasons; they reported that IWTs

- helped them to be more effective,
- helped them to be more creative,
- helped increase student motivation,
- helped stimulate student discussions and creativity, and
- directly related to student achievement.

A large body of evidence from the United Kingdom has shown the positive effects these technologies can have on teaching and learning (British Educational Communications and Technology Agency [BECTA], 2003; Cuthell, 2004). The research describes many affordances that help make teaching and learning more engaging for students and teachers. These include, but are not limited to, the following:

- IWTs allow for the presentation of a variety of representations (Kennewell & Beauchamp, 2003; Robison, 2000).
- IWTs have the potential to meet the needs of a wider range of learners (Latham, 2002; Levy, 2002).
- IWTs make it easier to incorporate a range of multimedia components, such as dynamic text, visuals, sound, diagrams, and online resources (Berque, Johnson, & Jovanovic, 2001; Ekhami, 2002).
- IWTs allow teachers to use material that has already been annotated to reinforce key concepts or to help learners make connections with past content to extend learning over a sequence of lessons (Glover & Miller, 2003; Walker, 2003).

Even though research into how these tools help support mathematics instruction is evident (Glover & Miller, 2003; Jones & Tanner, 2007; Miller, Glover, & Averis, 2005), the literature, although growing, is still somewhat limited. Moreover, critics of IWTs have stated that these tools perpetuate the didactic teaching methods of the past and do little to support a constructivist model of teaching (McCrummen, 2009; Nielsen, 2010). Although there exist different contexts that perpetuate didactic or traditional teaching methods, no matter which technologies are used, there is an important need to help teachers understand and maximize the potential of these tools in mathematics instruction. Therefore, this study is significant because it will add to the body of knowledge related to the effects IWTs can have in mathematics instruction to promote student achievement.

Definition of Key Terms

What follows is a list of commonly used terms in this study. These terms are listed here and defined within the context of how they relate to this study.

ActivBoard: A brand of interactive whiteboard (IWB).

ActivExpression: A brand of learner response system (LRS).

ActivInspire: A brand of lesson development software.

Algebra 1 End-of-Course (EOC) Assessment: “The Algebra 1 EOC Assessment measures student achievement of the Next Generation Sunshine State Standards (NGSSS), as outlined in the Algebra 1 course description” (FLDOE, 2011c).

End-of-Course (EOC) Achievement Levels: Four levels within which the EOC standardized exams fall as specified by the Florida Department of Education. Scores range from Achievement Level 2 (375) to Achievement Level 5 (437), with Achievement Level 3 (399) and above reflecting proficiency (FLDOE, 2011b).

End-of-Course (EOC) Standardized Test: “The Florida EOC Assessments are part of Florida's Next Generation Strategic Plan for the purpose of increasing student achievement and improving college and career readiness. EOC assessments are computer-based, criterion-referenced assessments that measure the Next Generation Sunshine State Standards (NGSSS) for specific courses, as outlined in their course descriptions” (FLDOE, 2011a, para. 1).

Interactive whiteboard (IWB): A large, touch-sensitive display that is connected to a computer and digital projector. The display allows users to interact with content via a pen/stylus or touch to manipulate objects on the screen.

Learner response system (LRS): A device that allows teachers to elicit in-the-moment feedback throughout the course of a lesson. The feedback is generally represented via a bar graph and types of questions can include multiple choice, true/false, numeric, or text response.

Summary

Recent scores from national and international math, science, and reading assessments have indicated lower achievement in mathematics for U.S. students as compared to their peers in other countries. Organizations like the International Society for Technology in Education (ISTE) and the NCTM (2000) are addressing these issues by providing guidance and standards on how technology can facilitate math instruction. Coupled with frameworks like the NETP (2010) and the Partnership for 21st Century Skills (2011), math education can explore new and exciting ways of integrating technology into existing curricula.

IWB tools are becoming more ubiquitous throughout U.S. classrooms. As such, these tools can be used to supplement math instruction in new ways. This research attempted to determine how the use of IWTs in Algebra 1 is associated with student achievement on the Florida Algebra 1 EOC Assessment. The key question that guided the data collection and analysis stated, "What factors influence students' scores on the Florida Algebra 1 EOC Assessment in four secondary Algebra 1 classrooms using IWTs?"

Chapter 2 will include a discussion of IWTs, teachers' and students' perceptions of the tools, how these tools can help facilitate learning, and how these tools can aid in the presentation of content to enhance understanding.

CHAPTER 2
REVIEW OF THE LITERATURE

IWTs are quickly becoming a salient technology in many U.S. classrooms. According to the marketing firm FutureSource Consulting (2009), one in six classrooms worldwide will have an IWB by the end of 2012. As more districts begin to implement IWBs as part of their technology focus, research on how these tools can help support teaching and learning is imperative. In order to better understand how IWBs can help support instruction, specifically in mathematics education, a review of the literature was conducted. The review focused on the tools themselves, teachers' and students' perceptions of the tools, how the tools can help facilitate learning, and how the tools can aid in the presentation of content.

The IWB is a large, touch-sensitive display that is connected to a computer and digital projector. The projector displays the image from the computer to the IWB, and users can interact with content via touch or a pen (BECTA, 2003). IWB manufacturers typically bundle IWBs with LRSs, or clickers (Figure 2-1), as they are often called, and lesson development software (Figure 2-2). The LRS provides teachers opportunities for gathering student feedback in a variety of ways (e.g., multiple choice, true/false, texting, etc.) throughout the course of a lesson. The data can be saved and/or exported into content management platforms, grade books, or programs like Microsoft Excel®. Data from the LRS are also stored as part of the lesson file and can be retrieved any time the lesson file is opened. Lesson development software allows teachers to recreate content that is more interactive by using a plethora of digital tools that can be used to annotate, record, and move objects. The software also allows teachers to save and archive files, as well as export lessons into common formats (e.g., PDF, PowerPoint, and Web pages) to share with students and colleagues. However, it is important to note that this software is not required in order to use the IWB, and teachers can interact with existing resources like PowerPoint® presentations, PDF files, and the Internet.

Since the IWB is at least bundled with lesson development software and sometimes with the LRS, the author uses the term *IWT* to describe the collection of the IWB, the LRS, and lesson development software. As such, the review of literature on IWBs will also include, where appropriate, a discussion of the LRS and lesson development software.

The author performed searches for the keywords *interactive whiteboards* on the Education Resources Information Center (ERIC), Education Full Text, and the JSTOR databases. These keywords were used because of their universal acceptance by IWB companies in describing this technology. Additional keyword searches were performed for *interactive displays*, *electronic whiteboards*, *digital whiteboards*, *smartboards*, *clickers*, *learner response systems*, *audience response systems*, *personal response systems*, and *classroom response systems*. These keywords were used to identify articles relating to IWBs and the LRS as part of the IWB toolset.

Interactive Whiteboard Tools

IWBs were first developed for office settings and later introduced into education (Greiffenhagen, 2000). Specifically, IWTs were first used in higher education, and in the 1990s, primary schools began to acknowledge their potential (Murphy et al., 1995; Stephens, 2000). Early literature on IWTs is mostly descriptive and based on action research methodologies that highlight teacher and student perceptions of the affordances of the tool (Cogill, 2003; Smith et al., 2006). Moreover, Higgins, Clark, Falzon, et al. (2005) described that most of these studies focused on the introduction of the new technology by *early adopters* (Rogers, 1983) and *missioners* (Glover & Miller, 2003), who had a vision of what the technology could achieve. A number of benefits were identified as potential affordances of IWT. For example, IWTs

- afforded the presentation of a variety of representations (Kennewell & Beauchamp, 2003; Robison, 2000),
- had the potential of meeting the needs of a wider range of learners (Latham, 2002; Levy, 2002),
- captured resources in a way that was more attractive to both teachers and students and was able to hold a student's attention more strongly (Ball, 2003; Higgins, Miller, Smith, & Wall, 2005; Kennewell, 2001),
- allowed teachers to use already-annotated material to reinforce key concepts or to help learners make connections with past content to extend learning over a sequence of lessons (Glover & Miller, 2003; Walker, 2003), and
- were perceived as meeting the needs of different learning styles and allowed teachers to create lessons that modeled abstract concepts more concretely to help learners deepen their understandings (Ball, 2003; Edwards, Hartnell, & Martin, 2002; Miller & Glover, 2004; Richardson, 2003).

When looking at the literature on IWTs, the author identified four key themes to help classify the research: (1) interactivity—how teachers use IWTs to interact with students and content both at an interface level and a cognitive level, (2) pedagogy—how teachers use IWTs to recreate content that is more engaging and interactive in nature, (3) productivity and motivation—how IWTs help teachers' productivity in terms of lesson planning and lesson delivery and how IWTs help motivate teachers and students alike with their capacity to deliver content in a variety of representations that allow for a more engaging learning experience, and (4) professional development—how professional development opportunities help teachers integrate IWTs into curricula in effective and sustainable ways.

Interactivity

One of most cited affordances of IWTs is their ability to make lessons more interactive. Although the definition of *interactive* can be vague, the literature on IWTs has highlighted several descriptions of the word. Glover et al. (2007) established a three-stage typology for identifying the interactivity of effective teaching using IWTs:

- **Supported didactic**: In this stage, the teacher uses IWTs simply for display or visual support for the lesson; the IWT is not used as an integral part of the content, and there is little interactivity or student input.
- **Interactive**: The teacher begins to incorporate visual, kinesthetic, and verbal stimuli, and IWTs are mostly used as an integral part of the lesson. IWTs are no longer seen as a novelty, but rather as a supporting catalyst to learning. However, IWTs are not fully integrated into the lesson, and their potential is not maximized.
- **Enhanced interactive**: At this stage, the teacher progresses from the interactive level to fully realizing the potential of IWT capabilities. The teacher is fully comfortable exploiting the affordances of the technology in ways that support and enhance the content. Also, the teacher provides opportunities for students to interact with the content both at interface and cognitive levels. Last, the teacher incorporates a wide variety of materials, ranging from the Internet to specific software to the LRS.

Using this typology, Miller et al. (2005) identified six common *manipulations* that are used in mathematics lessons to enhance interactivity using IWTs. These manipulations were conceived by observing 50 lessons in 12 schools over the course of 1 year. The researchers identified these manipulations as key to enhancing the interactivity between content and learner as teachers move along the continuum from supported didactic to enhanced interactive. Moreover, the greatest effect of interactivity was purported when teachers used combinations of these manipulations. Glover and Miller (2003) identified the six manipulations as follows:

- **Drag-and-drop**: matching a response to a stimulant and used for classification, matching, processing of data, the creation of questions arising from the dragging, and the organization of material

- **Hide-and-reveal**: opening a hidden response when the stimulant was understood and enabling material to be revealed as conceptual development takes place

- **Color, shading, and highlighting**: used for the collection of like terms, enhanced explanation, and analysis through annotation and reinforcement through greater emphasis

- **Matching**: equivalent terms by demonstrating meaning

- **Movement or animation**: used to demonstrate principles and to illustrate explanations

- **Immediate feedback**: from teacher, pupil, or LRS, sometimes arising from direct consequence of one of the other five methods

For example, the drag-and-drop manipulation describes a process by which a student picks up or moves an object on the IWB to another position and then drops it to another position illustrating some marked difference. Combining this manipulation with immediate feedback, such as commentary and/or responses to questions during the manipulation, provides a more robust interaction between content and learner. Consider the following vignette: Students can better identify equivalent fractions by using a fraction wall (Figure 2-3). As the blue line is dragged from one position to another (left to right), equivalent fractions are highlighted (made more pale) to show the comparison of equivalent fractions. As the manipulation takes place, the teacher can provide commentary on how equivalent fractions are made (e.g., using least common multiples) and elicit responses from students to questions like, “How does 1/3 compare to 3/9 on the fraction wall?” Using this type of interaction helps students make a more concrete connection regarding how equivalent fractions are related using multiple representations (Gillen, Kleine-Staarman, Littleton, Mercer, & Twiner, 2007; Kennewell & Beauchamp, 2003).

Levy (2002) reported several ways in which IWTs can be used to support interactivity both from teacher and student perspectives. Teachers in the study reported the following:

- IWTs helped free up time for interactive and task-related activities. Since IWTs allow teachers to be more efficient with the presentation and demonstration of the introductory parts of lessons, they provided more time for teacher-student/student-student interactions.

- IWTs provided an effective stimulus for student-teacher interaction. Teachers reported that the facility of students being able to annotate over resources helped spark discussions at a faster rate. Also, annotation allowed students to contribute to generating learning resources that could be reused.

- IWTs provided an effective way for students to present and discuss work. When students were able to present their work using IWTs, the tools allowed for more robust teacher-student/student-student discussion and feedback using the LRS.

Students also reported on the use of IWTs for facilitating interactivity:

- IWTs facilitated cohesive and participative whole-class learning. Students reported that using IWTs allowed the class to interact as a whole more easily and provided opportunities for everyone to join the discussions. One student noted, “We can do work together and the IWBs are there so all the class can work together” (Levy, 2002, p. 12). Another stated, “I like the [IWB] because they are big and everyone can join in on what’s going on,” and “I think it makes people more interested in joining in and learning” (Levy, 2002, p. 12).

- IWTs focused on teacher-student/student-student interactions. Students reported that IWTs are vehicles for supporting interactions that allow for the use of annotation and LRS components to elicit feedback that can serve as jumping-off points. In this study, student questionnaires did not reveal any significant difference on whether the use of IWTs made lessons more lively than other lessons. Levy reported that about 53% believed that this was the case; 47% were neutral on the question.

- IWTs provided a better and more enjoyable way to present and discuss student work. Students reported that using the IWTs helped them articulate the explanations of their ideas more concretely (with the facility of the digital tools) and helped elicit discussion using the LRS.

- IWTs saved time and helped lessons move along more quickly. Students reported that IWTs helped teachers become more efficient with regard to the ease and speed with which they were able to access pre-prepared material.

> Consequently, students spent less time writing and had more opportunities for discourse.

Glover and Miller (2003) described the IWB as well adapted to whole-class teaching because of its interactive nature. Students are more motivated with lessons because the IWB allows for a higher level of interaction; that is, “students enjoy interacting physically with the board, manipulating text and images” (BECTA, 2003, p. 3). Another study reported students’ use of a number program that allowed them to move numbers on a number line using a pen; this was more motivating to students because the lesson became more interactive (Austin, 2003). However, caution should be taken when looking at these studies since they suggest that most of the interaction is superficial in nature. As Schmid (2006) pointed out, most of the claims about interactivity may be better termed as *technical* or *physical interactivity*. Schmid, drawing on the work of Aldrich, Rogers, and Scaife (1998) stated that there exists a distinction between *technical interactivity*, which focuses on interacting with the interface (i.e., mouse clicks and button presses), and two other types—*cognitive interactivity*, which deals with how a learner interacts with the content through learning schemas (Anderson, Spiro, & Montague, 1984; Scaife & Rogers, 1996), and *sociocognitive interactivity,* which deals with the learning processes between teacher-student/student-student in the co-construction of knowledge.

Aldrich et al. (1998) provided suggestions on how to best define interactivity when working with technologies. They suggested that in order for a technology to be interactive, its focus should be on moving away from the level of physical interactivity or reactive interactivity (e.g., clicking and dragging) to a focus on cognitive interactivity. Also, a key element in describing interactivity is the design of activities that are engaging and enable the student to reflect, connect, and activate different forms of knowledge. Moreover, a type of cognitive interplay should exist, whereby internal and external representations arise based on different settings. Although the work of Aldrich et al. does not directly deal with IWTs, it provides a useful blueprint for improving interactivity with IWTs. Aldrich et al. proposed a set of design concepts for technology-rich lessons:

- **Accessibility and visibility**: The interactivity should facilitate *inferencing* as the student is directed through key components essential for the problem-solving or learning task.
- **Manipulability and annotatability**: The interactivity should annotate over content to make changes for a student's own purpose. Also, the student should learn by doing and building new examples that enable the student to make more explicit what is being taught.
- **Creativity and combinability**: The interactivity should allow the student to create new content using different types of multimedia to provide multiple representations of the concept being learned.
- **Experimentation and testing**: The interactivity should support a virtual hands-on approach, whereby the student is able to simulate or conduct experiments by manipulating different variables (e.g., Gizmos® from ExploreLearning).

Although the research by Aldrich et al. involved CD-ROMs, the concepts on interactivity are relevant to IWTs and can be used to help stimulate ideas on interactivity and content development.

At a more theoretical level, Haldane (2007) described how an IWB is not in itself interactive, but acts as a medium through which interaction may occur. The complexity and richness of the interaction is be based on how well the user takes advantage of the IWB's potential. In this context, the IWB acts merely as a medium through which information and messages are displayed, and it is up to the teacher to decide how that information is created and how it will be delivered. With that said, the technical affordances of the IWB are what influence how the teacher delivers the information.

Haldane (2007) centered the description of the IWB as a medium based on the work of Salomon (1979) and Kozma (1994). Salomon (1979) theorized that it is not the medium itself that influences learning; rather, the attributes of that medium help organize cognitive processes unique to that medium. Kozma (1994) later added that it is a medium's stability that determines how the medium can be best utilized. For example, a stable medium such as a book allows the learner to follow a sequence of events that can be revisited if re-teaching or reinforcement is needed. Also, a book provides the learner the ability to change the pace at which the learning takes place, allowing time for reflection. More transient mediums, like movies and television, sacrifice the learners' abilities to control the pace of the content, but they have the advantage of providing richer symbol systems. These symbol systems are not only more attractive and interesting, but they elicit a more emotional experience from the learner. However, the success of using transient mediums for learning largely depends on the learners' abilities to process information quickly and how well the information is internalized at that moment. Kozma suggested that using more stable mediums permit the learner to create cognitive keys that allow the learner to revisit information to establish understanding and make connections (Haldane, 2005).

During whole-class teaching, a common strategy teachers use to illicit student feedback is teacher-student/student-student dialogue (Frisby, 2010). This type of social discourse allows students the opportunity to receive guidance or peer collaboration about their ideas or skills—what Vygotsky (1978) calls the *wiser others*. Haldane (2007) described the interaction of ideas and exchanges between the teacher, student, and the IWB with the notion of *learning threads*; that is, as these interactions initiate further interactions, they are inevitably bound to each other—a process Haldane (2007) refers to as *casual interdependency*. From this, Haldane (2007) described a framework (Figure 2-4) that uses the metaphor of the *fabric of learning* to describe how interactions between teacher and student can be used to develop *threads of understanding* during the lesson. A planning process that makes optimal use of the technology can facilitate the threads that are created during the course of a lesson. This planning process involves

> choosing exactly what explicit knowledge to present, how it should be presented, when to use particular functionalities of the IWB, matching resources (virtual and touchable), evaluating the usefulness of electronic resources and comparing them with more traditional, tactual resources and matching teacher input with learner activities (p. 266).

As students contribute to a discussion, it helps them and other students who are listening to construct new concepts and ideas based on their past and current knowledge (Bruner, 1973). Questioning and contributing to the discussion helps students make connections between their own life experiences and the new knowledge put forward during a lesson. This form of tacit knowledge can be made more explicit simply through verbal discourse but can be enhanced through interactions with IWTs. As Haldane (2007) pointed out,

> modifying the displayed content by annotation, skipping back to previous screens or visiting a relevant Internet site known to the teacher, were among the examples of the IWB being used to enhance these important moments of interpersonal interaction (p. 260).

IWTs allow teachers opportunities to capture moments of cognitive interaction in order to scaffold the learning. In Haldane’s (2007) study, teachers revisited the cognitive keys created earlier in the lesson and expanded on misconceptions and curiosities by accessing content from previous lessons and unused content on the teacher's computer or by accessing the Internet. As new content was created during the course of the lesson, the teacher saved the original content alongside annotations made during the lesson for reuse and reflection. As one teacher stated, "I feel that they (pupils) have better recall when they see the pages that they added their own ideas to…and…it's a really quick and effective way of recapping before we start a new lesson" (p. 265).

As noted earlier, Miller and Glover (2003) suggested that interactivity is best suited for whole-class teaching. Research also suggests that IWTs engage students more than conventional whole-class instruction (BECTA, 2003). Moreover, it was claimed that whole-class teaching enables the teacher to interact more with students, adapt more quickly to student feedback, act upon misconceptions or errors at a faster rate, and keep students on tasks for longer periods of time (Muijs & Reynolds, 2001; Reynolds & Farell, 1996). More recent research has focused on *dialogic teaching*—how the power of classroom discourse can promote and enhance students' understanding during whole-class teaching (Alexander, 2003; Mercer, 2003; Mercer, Dawes, Wegerif, & Sams, 2004; Nystrand, Wu, Gamoran, Zeiser, & Long, 2003). Dialogic teaching proposes that the interaction be collective (i.e., students and teachers address the learning task together), reciprocal (i.e., students and teachers reflect on a collective mindshare of ideas and different viewpoints), and cumulative (i.e., students and teachers work together to create a collective string of thought and inquiry). It is important to note here that the NCTM (2000) has also promoted these strategies over the last several years. Specifically, the Principles and Standards for School

Mathematics have provided guidance on the tasks and processes needed for the successful implementation of high-quality mathematics instruction. These strategies provide math teachers with a framework for creating content that is relevant, engaging, and technology rich in ways that help supplement and enhance content for the understanding of mathematics.

However, research suggests these strategies are used less frequently; teachers still use traditional patterns of whole-class interaction, with teacher questioning and feedback only rarely being used to elicit deeper thought (English, Hargreaves, & Hislam, 2002; Hardman, Smith, & Wall, 2003; Mroz, Smith, & Hardman, 2000; Smith, Hardman, & Wall, 2004). Tharp and Gallimore (1988) called this type of discourse in whole-class teaching the *recitation script*. Sinclair and Coulthard (1985) stated that in its prototypical form, teacher-led instruction yields three phases: (1) an *initiation*, whereby the teacher proposes a question; (2) a *response*, whereby the student attempts to respond to the question; and (3) the *follow-up*, whereby the teacher provides feedback, usually in the form of an evaluation. This sequence of events typically consists of closed questions, brief student responses that are not explored, superficial praise rather than diagnostic feedback, and an emphasis on recalling of information rather than investigation and critical inquiry.

In a study of the impact of IWTs on whole-class teaching, Smith et al. (2006) observed 184 lessons in numeracy and literacy over a 2-year period. The study suggested that, although IWTs promote engagement, discourse, and faster-paced lessons, the underlying pedagogy of the recitation script remains largely unchanged. However, the study revealed that positive impacts can be observed with the use of

IWTs to help teachers move away from traditional approaches. For example, it was observed that teachers using IWTs used more open-ended questions during the initiation move; however, student feedback was briefer due to the faster pace of the lesson. Although IWTs can be a useful in the classroom, this research suggests that the technology alone will not bring fundamental change in the traditional patterns of whole-class teaching.

Jones and Tanner (2007) offered an analysis on the types of interaction that typically occur during whole-class teaching in terms of five levels:

- The lowest level of interaction is lecturing because interaction between student and teacher is rare. Internal interactions occur within the student but rarely influence the lesson in any meaningful way.

- The second level of interaction is through a rigid form of *scaffolding* that is based on “simple, low-level funneling questioning” (p. 38). In this level, the teacher decides the questions and, ultimately, the answers that will guide the students down a predetermined path toward a fixed solution.

- The third level is a more flexible form of scaffolding in which the teacher invites student-generated questions that allow the teacher to probe deeper into the students’ thinking. Through this interaction, students have more influence over the course of the lesson, albeit still orchestrated by the teacher.

- The fourth level of interaction offers a more dynamic form of scaffolding in which the teacher and student work collaboratively in the co-construction of knowledge. At this level, differences in perspectives are encouraged, and the teacher serves in the role of facilitator who validates conjectures and gives general direction by focusing questions to important aspects of students’ contributions. This level of interaction demands that teachers have high levels of skill since it requires them to think on their feet and respond to conjectures and strategies suggested by students.

- The highest level of interaction is collective reflection. At this point, the teacher encourages students to reflect upon discussions and activities that took place to initiate self-evaluation. These activities often take the form of self-assessments, journals, students writing their own examination questions, etc.

Jones and Tanner suggest that teachers use caution when using the IWB as a whole-class teaching tool because learning can become a sequence of rapid or instantaneous recall of fact rather than high-quality dialogue and understanding. As such, pace becomes prevalent in lieu of giving students time to think, organize, and offer more complex answers. Emphasizing pace in interactions discourages deeper understanding and extended time for student self-assessment and reflection (Kyriacou & Goulding, 2004).

Higgins, Clark, Falzon, et al. (2005) reported that although there is an initial increase in the pace of lessons with IWTs and fewer uptake of questions, after some time, teachers begin to use IWTs in ways that provide them with opportunities to ask more open questions, to probe, and to elicit longer responses from students. One way in which IWTs can facilitate higher levels of interaction is by providing teachers the opportunity to model concepts at a faster rate and with greater ease during class discussions. Therefore, teachers can focus more instructional time on engaging students with dynamic and reflective interactions and, thus, giving students more opportunities for collaboration, examination, and co-construction.

Muijs and Reynolds (2001) claimed that a whole-class teaching approach allows the teacher to interact more with each student, adapt activities more quickly to student feedback, use misconceptions as teaching points, and keep students on task for longer periods of time. However, they also noted that this approach is not always suited for all circumstances. Although IWBs can be used to enhance whole-class teaching interactions, research suggests that not all teachers are using IWBs to this extent (Ball 2003; Levy, 2002). Smith et al. (2004) reported that whole-class teaching using IWBs reduces the pace of the lesson because some pupils find the boards difficult to manipulate. Moreover, Thomas (2003) cautioned that some teenagers might be less apt to leave their seats than younger students when physically interacting with the IWB. Higgins, Miller, Smith, and Wall (2005), citing Levy (2002), state that some teachers believed the teacher-student interaction was enhanced “by encouraging students to offer answers to questions, which if correct can be noted on a flipchart” (Levy, 2002, p. 8) and supported by the “strong visual and conceptual appeal of the information and learning resources that are displayed” (Levy, 2002, p. 8). However, this method of instruction, akin to the previously mentioned recitation script, has been criticized because it limits the quality of student interactions and puts emphasis on the teacher as sole deliverer of information and critical evaluator who directs a prescriptive course for the lesson. In turn, students are given little opportunity to evaluate and reflect on the content and their understandings (Edwards & Westgate, 1994; Wood, 1992). As Higgins, Clark, Falzon, et al. (2005) explained, citing Mroz et al. (2000), this type of procedure “seeks predictable correct answers and only rarely are teachers’ questions used to assist pupils to more complete or elaborated ideas” (Mroz et al., 2000, p. 2).

In summary, IWTs seem to provide opportunities for both teacher-student/student-student interactions that are both physical (e.g., manipulating text or dragging objects) and pedagogic (e.g., social discourse) during whole-class teaching. For example, students in Levy’s (2002) study reported that watching and listening to peers’ explanations and interactions helped them articulate their ideas more concretely into their tacit knowledge. Other studies (Birch, 2003; Glover & Miller, 2003; Walker, 2003) showed that students were more apt to encourage each other when one class member was at the board. Carter (2002) argued that this could be due to a decrease in student anxiety because of the alterable nature of the work on an IWB. Burden (2002) suggested that the IWB could encourage an interactive environment where students are active participants in the reconstruction of knowledge. However, these affordances can be negatively impacted if IWTs are used to perpetuate the didactic teaching that often becomes prevalent in whole-class teaching, where students become mere spectators instead of critical thinkers (Paton, 2007).

Pedagogy

Teachers who use IWTs as a medium to engage students in meaningful and reflective discourse will begin to think more deeply about how content is created. Teachers reported that using IWBs and lesson development software allowed them to create more engaging and effective lessons that could be presented in a variety of representations to meet the needs of a wider range of learners (Iding, 2000; Kennewell & Beauchamp, 2003; Latham, 2002; Levy, 2002; Robison, 2000; Stephens, 2000). Equally, the software enables teachers to model abstract ideas and concepts more concretely and in new ways, allowing students to deepen their understanding of difficult concepts (Edwards et al., 2002; Kennewell & Beauchamp, 2008). In a small-scale study of Information and Communication Technology (ICT)-rich primary schools, Kennewell and Beauchamp (2007) found a new taxonomy for features of ICT—particularly for use with IWTs. The research involved a single lesson observation with six teachers teaching students in grades 3-5. The teaching tended to follow a four-phase lesson as described by Hughes (2001):

- **Phase 1**: Phase 1 is teacher led and usually involves a whole-class activity with the IWB as the main focal point. Full-class participation in the review of familiar concepts or activities is expected.
- **Phase 2**: Phase 2 is teacher led and usually uses the IWB and introduces new content requiring some scaffolding carried out as a whole-class activity in a way that students feel involved. Students in this phase interact with the content at the

interface level, responding to questions both orally and by using the LRS and by manipulating objects on the IWB.

- **Phase 3**: Phase 3 requires students to work in groups or collaboratively on content taught in Phase 2 or to explore concepts in greater detail. The teacher serves in the role of facilitator and usually walks around the class helping groups or working with one group while the other groups work independently or with learning aids, if applicable.
- **Phase 4**: Phase 4 features the closing of the lesson, which usually involves using the IWTs to reinforce key concepts or to review difficulties students might find. This phase has the potential for reflective activity on the part of students, but it is usually dominated by teacher-led, low-level questioning.

Teacher interviews revealed IWTs as being effective in stimulating thinking, maintaining focus, and gaining students' attention on the content rather than on the teacher or other students. Also, teachers described the use of IWTs as helping facilitate a variety of representations and making it easier for students to grasp more difficult concepts. Kennewell and Beauchamp (2007) noted several features of IWTs that help teachers easily implement representations in a variety of ways (Table 2-1). These features also help guide the structure of how the lesson can be developed using IWTs to promote a deeper understanding of the content by the student. Moreover, these features can also serve as guides for teachers seeking to maximize the value-add of using IWTs as effective pedagogical tools.

The features in Table 2-1 were divided into two categories—those that were intrinsic to IWTs and those that were constructed. The constructed categories can be classified as those created by the IWT designer/teacher preparing the lesson or created dynamically during lesson interaction, or by the students during the activity. The relationships between the affordances and constraints between these actions are listed in Table 2-2. In Kennewell and Beauchamp's (2007) study, teachers used features of the lesson development software to make content more relevant and explicit—by highlighting, labeling, annotating, and color cueing—for summarizing key points at the end of the lesson. It was also common for students to come to the board and interact with the content by dragging, manipulating text, or annotating their own content on pre-made resources. Although this slowed the pace of the lesson, both the student working on the board and the students watching were more engaged with the content. Moreover, a supportive culture was evident as the student at the board received feedback from peers based on their knowledge or skills regarding the content. Specifically, features of provisionality and feedback were evident in this case and provided a beneficial aspect to learning as they reduced the risk of failure for students.

As teachers become more proficient with the technology, they begin to think more deeply about how technology can supplement particular strategies in their teaching. For example, using the classifications described in Table 2-2, teachers and students can create content and can save and later retrieve it using *storage*, *capacity*, *automation*, *library,* and *linkage* features. A teacher can save the new version and show students the same exercise completed by students during the previous year or the previous period by placing it alongside the current class version. The intrinsic features of IWTs—retrieval, collating, and comparing—and the constructed features—library and speed—allow the teacher to create richer and more explicit learning experiences for students. The features of IWTs have the potential to support new forms of interactivity in teaching and more instances of participatory pedagogy (Beauchamp, 2006). Last, as teachers begin to become more proficient with IWTs, the combination of these features, alongside the manipulations suggested by Glover and Miller (2003), provide a foundation for developing a framework to describe an interactive classroom.

An interactive classroom contains a confluence of discourse between teacher, student, and content. Specifically, an interactive classroom is defined by how students engage in cognitive interactions with the content and how teachers serve in the role of facilitator where “students’ contributions are encouraged, expected and extended” (Department of Education and Employment, 1998, p. 8). This implies that student participation is more autonomous than the traditional recitation script described by the initiation-response-feedback (IRF) model (Sinclair & Coultard, 1975). However, several studies have identified that this is not the case, and most classroom interactions still prescribe to the IRF model (Galton, Hargreaves, Comber, Wall, & Pell, 1999; Hargreaves et al., 2003; Mroz et al., 2000; Myhill, 2006; Smith et al., 2006). Pace also plays an important role in how content is understood, and although IWTs are reported to quicken the pace of lessons, this may be at the expense of discussion and extended responses. An emphasis on pace reduces the time for student reflection and can contribute to teachers asking more and students saying less (Burns & Myhill, 2004; Edwards & Westgate, 1994; Wells, 1999). As such, the triadic discourse between teacher, student, and content is reduced, and instructional strategies like scaffolding and *chunking* may not be as prevalent.

Hargreaves et al. (2003) derived nine different types of interactive teaching from teachers’ descriptions and interpretations of interactive teaching. The nine types of interactive teaching are classified into two main categories: (1) *surface* forms, which are associated with gimmicky-type features/techniques (e.g., games using hide-and-reveal actions or using the LRS for low-level questioning) and (2) *deep* forms, which represent deeper levels of engagement to probe students’ understanding and provide opportunities for reciprocal interaction for the co-construction of knowledge and student reflection—these tend to be less developed in practice. The key features of surface forms include engaging students, students' practical and active involvement, broad student participation, collaborative activity, and conveying knowledge. Deep forms include assessing and extending knowledge, reciprocity and meaning making, attention to thinking and learning skills, and attention to students' social and emotional needs. This suggests that interactive teaching should include a variety of IWT and non-IWT methods and lessons.

An example to illustrate the aforementioned ideas is provided in the following vignette:

One of the harder concepts to teach algebra students is the process of identifying a function using relations. To introduce relations, a teacher will typically begin by defining a *relation* (i.e., a relationship between sets of information). For example, the pairing of students' names with their weights is a relation. Each pairing will have a unique order—the pair can be ordered by student name and corresponding weight or by weight and corresponding name. Mathematically, each pairing has a starting and ending point. The starting point of a relation is called the *domain,* and the ending point is called the *range*.

In order for a relation to be a function, the relation must be *well behaved*. Mathematically speaking, when a relation is well behaved (i.e., a function), every member in its domain (i.e., starting point) must have exactly one unique member in its range (i.e., ending point). From this, one can infer that all functions must be relations, but not all relations are functions. Suppose the following relation was shown: {(-

1,3),(2,4),(3,2),(-1,1)}. Is this relation a function? At this point, students begin to interpret the definition expressed in the vignette in different ways. As KennewelI and Beauchamp (2003) suggested, IWTs offer teachers the ability to present a variety of representations. As such, in the example above, students can be shown two alternate representations to help direct their learning and deepen their understanding. One representation involves using a diagram called a *mapping* (Figure 2.5a) to determine if a relation is a function. Students can interact with the diagram to test their initial thoughts by initiating a sequence of actions or manipulations (Miller et al., 2005) while receiving feedback from their peers as the teacher serves as facilitator to guide the discussion. This representation can be coupled with a second representation to help students make more explicit connections. A second representation (Figure 2.5b) using a Cartesian graph can be added to the mapping to help students conceptualize a different way to approach the question.

Next, the teacher can call on a student, then a different student to work on the IWB alongside the first student in order to find relationships between the two representations that will ultimately lead the students to form conjectures about relations and functions. Also, in order to get a better sense of how each student understands the content, the teacher can use the facility of a self-paced mode using the LRS (i.e., sending questions to the devices so that each student can complete each question at an individual pace). Last, the teacher can give students the opportunity to create their own models of relations that are both functions and non-functions. Using the features of IWTs to illustrate the concept of a function through interface interactions (i.e., drag-and-drop, drawing, and annotating) and eliciting feedback from students using either the LRS or having them work on the board (simple forms of interactive teaching) provide a good start for creating a richer interactive experience. Providing opportunities for students to create new examples/non-examples based on the content (e.g., new relations that may/may not be functions) and allowing discourse between teacher-student/student-student take advantage of deeper forms of interactive teaching. This vignette shows a practical example of how IWTs can help teachers develop more effective lessons using the typology of interactive teaching to present a variety of representations (Stephens, 2000; Kennewell & Beauchamp, 2003) to help students deepen their understanding.

As teachers recreate content using IWTs, digital copies are made that can be saved and later retrieved. Kennewell and Beauchamp (2003) reported that teachers who are connected to an Intranet can also share digital copies with staff, which may help reduce teacher workload. These copies can become a collection of artifacts that teachers can archive and later reuse or share with other teachers, parents, and students. Also, with the advancement of new Web 2.0 technologies and mobile devices, these artifacts can be accessed through a variety of mediums. As such, students and teachers have better access to content to help reinforce key concepts learned in class. For example, IWTs allow teachers to record their content (both IWB actions and verbal actions) and save their recordings in audio or video format. These formats can be uploaded to websites like YouTube®, TeacherTube®, Facebook®, or class websites and can be accessed by students, parents, or other educators (Figure 2-6). These artifacts can also be loaded onto mobile devices using open-source software (Figure 2-7). The benefits of having digital content on the Web is two-fold: (1) access—content can be accessed by anyone, anytime, and anywhere, and it can be replicated, repurposed, and enhanced by the larger community to meet the needs of a wider range of learners and (2) portability—by having content readily available, students have more opportunities to learn, relearn, or review content, and parents and/or tutors have access to expert content that is increasingly relevant to the needs of the students.

Another key benefit of using IWTs is the ability for teachers to quicken the pace of lessons by using prepared material to smooth lesson transitions by reusing material to reinforce key concepts. The facility to use and reuse materials that have been annotated can also be used to extend learning over a sequence of lessons (Ball, 2003; Glover & Miller, 2003; Latham, 2002; Miller & Glover, 2004; Walker, 2003). Moreover, Levy (2002) summarized how using activity-based learning as a pedagogic approach can help teachers become more aware of the advantages of demonstration, resulting in a reduction in the time to prepare teaching materials and the greater use of a plethora of information resources that allow for more independent learning.

IWTs were also identified as tools that make it easier to incorporate multimedia resources like video, images, flash simulations, sound, diagrams, and online websites (Ekhami, 2002; Levy; 2002). Adding multimedia resources is key for helping students gain more concrete representations of concepts— simply relying on one program inhibits optimum use of the IWTs as both presentational and pedagogic devices (Higgins, Clark, Falzon, et al. 2005; Miller & Glover, 2004; Reedy, 2008). Content that incorporates different resources is more attractive to both students and teachers and captures and holds students’ attention much longer than other traditional resources (Ball, 2003; Higgins, Miller, Smith, & Wall, 2005; Kennewell & Beauchamp, 2007). Burden (2002) noted that teachers claim their students have better recall of information when stimulating visuals are used, citing, “when I talk to the children about what helps them remember, they say they can still see the images in their mind, even after we have finished a lesson” (p. 7). IWTs also enable a smoother and better-paced introduction of content by the teacher than would have been previously possible. Mercer, Warwick, Kershner, & Staarman (2010) reported that teachers use IWTs to engage students' interest and guide their new knowledge by providing information in a variety of contexts and formats. Likewise, lesson development software that is bundled with IWBs makes it easier for teachers to build more dynamic lessons by making use of the digital tools embedded within the software. In a study by Zevenbergen and Lerman (2008), teachers commented that having the tools available in one place meant they did not waste time looking for them, which resulted in faster-paced lessons. Thomas (2003) reported that using the interactive features like drag-and-drop, embedding of video and sound, and capturing still frames gives teachers the opportunity to meet a wider range of learning styles. For example, Thomas cited several uses with language learners, such as using jumbled sentences that can be moved across the screen and arranged into logical sequences. Also, the ability to embed recorded sounds alongside contextual visuals helps prompt students to complete certain tasks. Thomas states,

> It [IWB] breaks up the lesson and brings the reality of French life into the classroom. Since the clips can be triggered instantly, you can watch them in any order or call them back whenever you want. You can't do that with a cassette and a television (p. 28).

Several other affordances, such as annotating, concealing/revealing, manipulating, moving and zooming, and displaying sharp colors on a large display have been suggested to enhance the learning process (Damcott, Landato, Marsh, & Rainey, 2000; Levy 2002). For example, Edwards et al., (2002) show how manipulation and color of visuals facilitate learning using fractions (Figure 2-8). In their study, very low-attaining 11- and 12-year-old students were given a series of differently colored shapes and were asked to write on their own non-IWBs the percentage of the whole shape that was covered. The teacher, in this instance, highlighted the whole shape and, separately, the colored area. This approach helped students visualize more explicitly how the parts of a whole are related to the whole.

The ability to present content with an array of multimedia resources is said to help students. Not only is there a wider assortment of information available, but there is also a wider range of the types of information available. This proves useful for teachers who can pull in resources that make difficult concepts easier to grasp (Levy, 2002). As such, teachers also have the facility of pinpointing resources that can meet the particular needs of the learner (Bell, 2002; Billard, 2002; Glover et al., 2005).

Although strong benefits on the use of multimedia resources and multi-sensory representations have been reported, some research cautions about how these resources are used. Higgins, Clark, Falzon, et al. (2005) argued that it is not known whether verbal and visual information presented together optimizes the learning or if dynamic visuals provide better understanding than static visuals. Moreover, simply presenting a process with the aid of visuals, whether static or dynamic, does not “miraculously produce understanding of that process” (Goldman, 2003, p. 240). Furthermore, using visuals as a key approach to learning depends more on the subject matter and how those visuals are arranged with text and verbal information to form connections and highlight important information while removing irrelevant information (Mayer, 2003). Last, it is important to consider how information is displayed and whether using too many multimedia resources muddles the information. Seufert (2003) stressed that using multiple representations to construct knowledge largely depends on the student’s prior knowledge and how well the student can convert explicit knowledge into tacit knowledge. She argues that less-able students find this difficult and often focus on one representation, “often the more familiar or concrete one” (p. 228).

The following case study by Hennessy, Deaney, and Tooley (2011) illustrates the aforementioned strategies found in the literature on how using IWTs can enhance pedagogy. The case study offered an example of how an expert secondary science teacher used IWTs and other digital resources to support active learning to a class of ninth-grade students learning the process of photosynthesis. This research was part of a larger project named T-MEDIA that used digital video to analyze and document how secondary teachers used IWTs and other digital resources to support subject learning. Hennessy et al. (2011) took a collaborative approach by collecting video recordings to demonstrate how and why successful approaches work. The methodology paralleled similar studies that used video recordings as the key tool in capturing the complex processes of classroom interactions (Armstrong & Curran, 2006; Powell, Francisco, & Maher, 2003; Sorensen, Newton, & Harrison, 2006). A systematic categorization of teaching modes across six 1-hour lessons showed that IWTs were used for direct whole-class teaching for 43% of the total lesson time, pair/individual work related to the IWB took 9% of the total lesson time, work without IWTs took 42% of the total lesson time, and mixed mode activities took 6% of the total lesson time.

The teacher, named Chris, created or sourced from the Internet most of the resources for the lessons. He used lesson development software to create interactive activities that allowed for instant feedback through manipulations like drag-and-drop, hide-and-reveal, and annotation. These activities were complemented with the use of high-quality visuals, diagrams, video vignettes, and animations that showed the microscopic structure of a leaf, allowing students to “[see] the whole leaf and actually diving into it” (Hennessy et al., 2011, p. 106). His first key strategy was fostering active involvement by providing opportunities for active involvement using IWT-supported activities, discussion, and scientific thinking. He felt the need to stay clear of using the IWB as a glorified overhead projector and mainly operated the IWB himself since manipulation by students was deemed of secondary importance and was time consuming. Chris stated, “The most important thing is that they’re actively learning in whatever sense . . . It can be interactive at a cognitive level rather than a physical level” (Hennessy et al., 2011, p. 108). Chris ensured class participation and involvement by asking students to vote or by canvassing opinions. Although the LRS was not used in this case study, this episode serves as an example of how the LRS can be used to keep all students engaged by providing opportunities for immediate feedback to guide the course of the lesson. Also, it gives students a safer forum to express their thinking without speaking out in class or coming to the board. A second strategy was using student-created diagrams and visual aids as a way for students to generate their own memory aids. Asking learners to create their own diagrams and notes was part of a wider view of IWTs, which worked to increase cognitive engagement for students to visualize themselves in particular scenarios related to the concept being taught. Chris used this strategy to help students move away from the didactic approach of simply copying notes into their notebooks without thought of what was being written. He encouraged students to write vignettes describing their diagrams in a way that made sense to them and provided a way for Chris to assess how students were learning the content being taught. He stated,

> You can really model what you are doing on the board and then talk though different examples, but very much the emphasis [is] on them to think about what for them will be memorable and for them to take control of their learning…we've led them up to this point but it's time for me to fade now and then even to withdraw from it. (Hennessy, 2011, p. 110).

In summary, IWTs allow teachers to create more engaging lessons through the use of a multitude of resources. Specifically, lesson development software makes it easier for teachers to embed multimedia components that help make abstract concepts more concrete and makes their workflow more efficient. These tools also allow teachers to have ready-made resources at their fingertips to use for remediation, re-teaching, ad hoc explanations, or to simply make more explicit interactions with the content.

Furthermore, the interactions that take place on the IWB can be captured through video and replayed as part of a teacher's strategy for intervention, re-teaching, or enriching. Even though these affordances tend to be more toward technical interactions, some authors (Bell, 2002; Damcott et al., 2000; Glover & Miller, 2003; Kennewell & Beauchamp, 2003; Levy 2002; Stephens, 2000) suggested these technical interactions help activate methods and teaching styles that are more interactive and constructivist in nature.

Productivity and Motivation

One of the most cited advantages of IWTs is their affordance to motivate pupils, which leads to improved attention and behavior (Beeland, 2002). As Beauchamp and Parkinson (2005) stated, " . . . clearly the IWB is a lot more exciting than the blackboard and overhead projector, and pupils will be curious to find out about its functions and capabilities. As a result, they might pay more attention than in the past" (p. 97). Students reported that the faster pace of the lessons made them more fun (Levy, 2002). One can attribute this to the ability of IWTs to easily incorporate a wide range of multimedia resources that make it easier for teachers to access content. Moreover, using different types of multimedia connects students to resources they see and use in their everyday lives (Beeland, 2002; Glover & Miller, 2002). Teachers also seemed more motivated to use the IWB and recreate some of their lessons, and this influenced students' perceptions (Cogill, 2002). By creating lessons that incorporated the reveal, show/hide, and other techniques, students appeared more interested, and their zest for learning was enhanced (Glover & Miller, 2003; Levy, 2002). Other reports showed that IWB use is more motivating to teachers because it provides easy access to materials (Balanskat, Blaimer, & Fefala, 2007; Levy, 2002). Balanskat et al. (2007) reported that students are more engaged because the board is large, and the contents are easier to see. Levy (2002) also reported that the multimedia and interactive functions help students make better connections, and younger students have come to expect lessons to be more visually enhanced.

Although teachers found the use of IWTs rewarding and motivating, Armstrong et al. (2005) explained that in order to be competent in the use of IWTs, teachers need daily access to such tools so they are able to hone their skills and integrate them into practice. To illustrate this point, Wall, Higgins, & Smith (2005) explain,

> IWBs can facilitate and initiate learning and impact on preferred approaches to learning. The pupils describe how different elements of software and hardware can motivate, aid concentration, and keep their attention. On the negative side, pupils candidly describe their frustration when there are technical difficulties, their desire to use the board themselves and their perceptions of teacher and pupil effects (p. 851).

Greiffenhagen (2000) further argued that teachers must incorporate IWTs into the regular practice of classroom life in order to fully realize their potential. Teachers also reported the importance of sharing materials and how IWTs allowed them to do so with ease; however, they did expect a “*quid pro quo* with colleagues in terms of perceived effort that was put into preparing resources” (Kennewell & Beauchamp, 2007, p. 230).

While IWTs are reported to have many positive motivational features, Schmid (2006) reported that some students did not like the openness of their responses during discourse since they were available to public scrutiny, and they felt threatened and less likely to participate. It should be noted that this issue, which will be discussed later in Chapter 2, is not as prevalent with the advent of the LRS.

Also, students and teachers are more motivated to have deeper dialogical discourse during lessons by using the LRS (Marzano & Haystead, 2010). Using the LRS allows teachers to attain immediate feedback from each student and allows the teacher to make informed decisions based on the feedback to guide the course of the lesson. Marzano & Haystead (2010) reported that teachers find their lessons more interactive because each student is more actively engaged with the content. However, once the teacher has exhausted all IWT routines and the *wow* factor has passed, these pupils might revert to less attentive behavior (Beauchamp & Parkinson, 2005).

Motivation was another factor that contributed to change using IWBs. According to Glover and Miller (2003), motivation was enhanced when using IWTs, and there were 14 references to improved behavior for some or all students from the teachers. Teachers suggested the following:

- Distracted children pay attention for longer periods. Students are more willing to participate and are less self-conscious in front of others.

- Students have a zest for learning that stems from the element of surprise a teacher (and the software) can maintain.
- Pupils are more ready to participate and are less self-conscious in front of others.

One last component Glover and Miller (2003) studied was the availability of the IWBs for teacher use. The authors concluded that teachers with access to the boards were clearly more enthusiastic. Their comments are summarized below:

- Technology integration in all aspects of teaching required a reconsideration of the ways in which children learn.
- Technology integration enhanced understanding of the learning process, increased individualization of learning programs, and showed strong evidence that teachers were more aware of individual learning styles.
- Technology integration led to a period of planned change in each of the schools with introduction taking place in a measured way over five terms and involving parents in the learning process.
- Technology integration was achieved within a framework of corporate planning, shared resources, and peer support, involving all staff in the process of change.

The authors concluded that in order to successfully integrate IWTs, three conditions must be met:

- Teachers need a will to develop and use the technology. In this study, the authors pointed to the missioner of each school who was prepared to develop the necessary materials and assets for its use. The missioner used these assets to convince headmasters and governors of the potential of pedagogic benefit to increase student achievement and to inform them about how these interactive tools can be used to enhance classroom teaching and learning.
- There needs to exist a willingness on the part of the teachers to become mutually interdependent in the development of the materials. Technological problems need to be addressed and corrected; otherwise, teachers will become unconvinced of the benefits of using IWBs.
- There must be a change in thinking about the way classrooms are structured and how activities are resourced. If teachers are not willing to change their didactic approach to teaching, then there is no point in introducing IWBs since the technology will revert to old norms.

Professional Development

With the advent of the No Child Left Behind Act of 2001 (NCLB, 2002), many states now require that 25% of federal technology funds go toward professional development (Ansell & Park, 2003). With the introduction of the NETP (2010), the National Educational Technology Standards for Teachers (NETS*T), and state technology plans, a concerted effort has been made to facilitate the integration of technology for teachers and students. Many experts agree that the successful integration of technology largely depends on the effectiveness and timeliness of professional development for teachers. Data indicate that when integrating new technologies into curricula, most of the funding is spent on the hardware and software components and less on the training of the new technologies. Ansell and Park (2003) state, “Market Data Retrieval reports that almost 66 percent of school technology spending is projected to go to hardware and a little more than 19 percent to software. Staff development is expected to capture 15 percent of most schools’ technology budgets” (p. 44). According to the 2009 U.S. Department of Education’s *Teachers’ Use of Educational Technology in U.S. Public Schools* report, only 25% of teachers reported moderate to major training in educational technology in their undergraduate programs, and 33% reported such training in graduate programs (Gray, Thomas, & Lewis, 2010). Moreover, national data revealed that half of the teachers in our teaching force consider themselves to be beginners on the integration of technology into curricula (NCES, 1999-2000). Last, research evidence suggested that the lack of high-quality teacher training is a key factor impeding the successful integration of technology into curricula (Hubbard & Levy, 2006; Legutke, Mueller-Hartmann, Schocker, & Ditfurth, 2007).

Clearly, the need for professional development is imperative if the integration of IWTs is to be successful. Miller and Glover (2007) examined the approaches to professional development of staff in mathematics departments for seven secondary schools using IWBs. There exists little research on how teachers adapt practice and pedagogy into teaching using IWBs (Glover et al., 2005). However, taking a broader look at teacher training and technology led Miller and Glover (2007) to conclude that "school-based and individualized support appears to offer the most effective way forward" (p. 319).

Teachers in Miller and Glover's (2007) study favored support characterized by hands-on constructivist approaches (Coupal, 2004; Polyzou, 2005), mentoring by peers or staff members (Cuckle & Clarke, 2003), and shared learning experiences (Levy, 2002; Triggs & John, 2004; Williams, Coles, Wilson, Richardson, & Tuson, 2000). The authors note that there is a difference between technology training, which typically focuses on the computer as the tool; training with IWTs, which deals with the technical competence, software, and mechanics of its use; and pedagogical, subject-specific training, which deals with the integration of the IWTs. The aim of the study was to ascertain participants' perceptions of the induction of IWBs and how it impacted classroom practice. Seven schools were studied from a range that included rural, semi-rural, and urban contexts. Lessons were observed and recorded, and interviews of teachers and staff were conducted. The initial phase included 42 complete mathematics lesson recordings and 46 lesson recordings during the second visit, which the authors called the developmental stage. The results showed that teachers who had peer interaction as part of the professional development induction process were more likely to work together and share resources. However, in three schools, results revealed that not all teachers showed the necessary effort to promote change. The teachers in Miller and Glover's (2007) study reported,

- "We must not forget the work that has gone into developing the strengths of the current course in the school and would not want to lose things like sorting cards, or other practical activities that can teach as effectively as IWTs" (p. 325).
- "It is only one of the tools available to us and so it needs to fit into the general teaching pattern" (p. 325).

The typology used was adapted from Glover et al.'s (2007) previously mentioned earlier work and included three levels of development:

- **Supported didactic**: This approach supported the teacher using IWTs merely for visual display and not as an integral part of the development.
- **Interactive**: This approach incorporated visuals, verbal, and kinesthetic cues that enhanced the didactic level and was integrated into the teaching and learning; however, full potential was not developed.
- **Enhanced interactive**: This approach is a progression from the interactive level as teachers start thinking about how the technology can become a salient part of their teaching and tapping into more cognitive processes as they relate to IWBs.

Glover and Miller (2003) suggested that in order for a school to have effective practice and professional development using IWBs, there must be a missioner who can serve as a mentor and go-to person to help teachers become more comfortable and efficient with the integration of the IWTs. Traditional professional development is limited because off-site lectures are away from the hands-on environment teachers need with the IWTs. In essence, the authors suggest that the introduction of technology without sufficient training in technology and teaching may inhibit the full realization of the tool. Also, in order to promote positive outcomes for IWT use, a carefully managed induction phase supported by some level of expertise is recommended. Staff in the study suggested that once there is some level of knowledge of the technology, the greatest need is for the team of teachers to be able and willing to share experiences and grow together in providing more lively and challenging teaching moments. The authors recommended "that for effective professional development of mathematics teachers need to work with either an internal or external mentor from an early stage and be allowed time for exploration, consolidation and the development of teaching materials as confidence and competence develop" (Glover & Miller, 2003, p. 330).

Miller and Glover's (2003) research also revealed how IWTs can help facilitate pedagogic change by rethinking the ways in which these tools are introduced into the classroom. Evidence was collected using questionnaires, structured interviews of teachers and headmasters, and lesson observations. In order to investigate change, the authors cited the work of McCormick and Scrimshaw (2001), who indicated that the potential of teaching with IWBs might not be realized unless there was some type of pedagogic change. However, even when pedagogical aims were the goal, earlier researchers have identified the following problems using IWBs:

- inadequate staff training and limited development of IWB teaching skills;
- the use of considerable teacher time in the preparation and presentation of lessons;
- the use of inflexible approaches with limited student interaction driven by the prepared material; and
- the possibility that after a period would lose its novelty of time, the technology would lose its novelty, and teachers would revert to conventional methodology (Glover, Miller, Averis, & Door, 2004; Greiffenhagen, 2000; Lopez, 2010).

However, Greiffenhagen (2000) also argued that the availability of IWTs would only reach their potential if they became a salient part of classroom life. Respondents to Miller and Glover's (2003) study were asked to rank five advantages most frequently claimed for IWTs as teaching tools. The results have been reprinted in Figure 2-9. One of the top advantages teachers mentioned was the tightness of how they developed their lessons. Since teachers were able to use a multitude of resources and were able to visualize the content, it helped them make more concrete decisions about what to teach. Specifically, teachers noted that when using the lesson development software, which is bundled with the tools, they were able to create the lesson in a way that allowed them to organize their content much more efficiently. This was due to the fact that the software allows teachers to embed all of their content (e.g., visuals, multimedia, and links to the Internet) in one place. As such, it offered a way to structure content in a more thoughtful way. A surprising result was that teachers ranked as least significant the ability to print lesson notes for later use. As one teacher pointed out in rebuttal:

> It has provided a more efficient start to subsequent lessons, provided the means of running off material for pupils who have been absent, and it gives pupils a chance to be responsible for going over ideas or material they might have not followed the first time (p. 11).

Haldane (2010) described a study of how teachers acquire proficiency in the use of IWTs using a process of transformative personal development (TPD). The study suggests that teachers are less likely to realize the full potential of the tools' capabilities if training focuses on the tool itself without thought about the pedagogy it supports. Haldane (2010) uses the Continuing Professional Development (CPD) model as the basis for forming a typology that focuses on the progression of skill and pedagogy when using IWTs. Drawing on the work of Pearson, Haldane, & Somekh (2004) and Somekh et al. (2007), the author described that teachers who made successful use of IWTs did so by having a collaborative work-embedded CPD processes sustained over an extended period rather than a single training event (Cordingley, Bell, Rundell, & Evans, 2003; Cordingley, Bell, Thomason, & Firth, 2005). In essence, developing technical skill fluency parallel with pedagogic fluency in the classroom appears more successful than attempting to build technical fluency, then pedagogic fluency. In order to achieve this level of proficiency simultaneously, Haldane (2010) proposed the TPD model based on two critical factors:

1. Participants need to be guaranteed access to the technology regularly and frequently in order to hone their technical skills and feel confident about its use.
2. A process of sustained, collaborative learning based on shared experimentation and reflection is crucial. This can be achieved in small groups, including just two or three socially and logistically close people—a nuclear community of practice—so that full proficiency can be achieved.

The process of developing IWT skills and pedagogy is consistent with the findings of Hooper and Reiber (1995), whose research was conducted on the integration of an earlier generation of technologies. The authors suggested that teachers tend to follow a set of well-defined stages as they progress through their use of technology. Haldane's (2010) study showed similar stages, and a five-phase typology was created to describe the experiences of IWT users in the study (Figure 2-10). The following is a description of the proficiency levels used in the diagram:

- **Foundation (Level 1)**: At this level, teachers use IWTs primarily as display devices and drive the content using their computers. Often, teachers are positioned next to their computers and simply use the mouse and keystrokes to manipulate the content.
- **Formative (Level 2)**: Teachers at this level use the board with the digital pen and eraser for simple interactions. Typically, they click through a series of actions that are rudimentary in nature (hiding/revealing) and invite students to make the same types of manipulations. Teachers at this level are more likely to progress to higher levels if no blackboard/whiteboard is present.
- **Facility (Level 3)**: At this level, teachers use a more robust set of tools on the IWB, and they use these with greater confidence. They also begin the process of recreating lessons that make use of the interactive features of the tools. Moreover, they begin to incorporate more dynamic features like the use of *actions*

to make content more interactive. Teachers begin to feel like they have mastered the most advanced skills of the tools and feel very confident in their use.

- **Fluency (Level 4)**: At this level, teachers realize there are more intricate interactions that can take place using the facilities of the tools. They become *hunter-gathers* and actively seek out and harvest new ideas, concepts, and content to incorporate into existing lessons and curricula.
- **Flying (Level 5)**: At this final level, teachers are true virtuosos with the technology. They use a plethora of different instructional strategies to integrate with the tools and think critically about the different types of interactions to elicit deeper understanding from students. They adapt quickly and efficiently to student questions and demonstrate a smooth transition into incorporating different resources to help in the understanding of content.

This typology formed the basis for the TPD model alongside elements of the CPD provision of action research and sustained, collaborative situated learning. The typology is a starting point that sets the stage for a four-stage IDEA (Figure 2-10) sequence of events that describes the process of teachers attaining some limited subset of affordances of the technology and then gaining more experience applying it in the classroom before moving on (Haldane, 2008). The IDEA model describes in greater detail how teachers move along the continuum described in the model above. It is important to note that as teachers move through these progressions, they do so through shared experimentation and work-based learning over a period of time and not as isolated events in their own classrooms. IDEA (Figure 2-11) is an acronym that stands for Inquire, Discover, Explore, and Acquire with the following descriptors:

- **Inquire**: “How can I do this?” There is a need for skill development and technical affordances of the tool.
- **Discover**: Often, some useful functionality, over and above the simple answer, also emerges.
- **Explore**: Considerations are made and trials take place regarding how the newly discovered skills or functionalities of the tool can be integrated into existing pedagogy.

- **Acquire**: New ways of working, synthesizing, and embedding IWT skill combine with an emerging IWT pedagogy (Haldane, 2010).

In summary, Haldane's (2010) model provides insight into effective professional development when integrating IWTs into the curriculum. Her TPD process helps describe how teachers with initial limited technical skills can begin to explore the pedagogic potential of the technologies, and over time, develop their technical skills in tandem with the evolution of their pedagogies.

Schmid and Schimmack (2010) reported findings of a research project that investigated a model of IWT training for language teachers. The model comprised two phases: (1) a *bottom up* approach in teacher professional development in Computer Assisted Language Learning (CALL) and (2) a framework based on the sociocognitive view of communicative language teaching. Data from the research project reveal that teachers' use of the technology is greatly influenced by their competence of technical skills in using IWTs and their confidence in their use. Much like the teachers in Haldane's (2010) study, teachers reported that unless there was ample time to explore the affordances of the technology, they were less likely to maximize its potential. As two teachers stated,

> Teacher 1: "That's the problem: I cannot imagine what else we could do. If the imagination were there, I would have liked to go into it and profit from it, but so far…I don't see what else I could do" (Schmid & Schimmack, 2010, p. 202).
>
> Teacher 2: "It's like having a Porsche in the backyard and you only drive on the first gear, you think you could do so much with it, but you don't know how to do it" (Schmid & Schimmack, 2010, p. 202).

Schmid and Schimmack (2010) suggested that in order for training to be successful, the structure and content of the training sessions should be focused on pedagogy and should be subject specific. Within the context of the study, the authors also noted that teachers saw the need for the IWT training to be rooted in solid language learning theory and based on the investigation of their practice and specific pedagogical needs. Teachers also valued the use of concrete examples or complete lessons that helped them see the value-add of the technology in ways that enhance teaching and learning. Similarly, teachers reported that it was important to have hands-on training since simply watching a demonstration of what the technology could do would not encourage or enable them to use the tools in their lessons.

In order to fully maximize the potential of IWTs, training sessions should include the following competencies:

- exploring the technology so that teachers become confident in its use—teachers who do not feel confident are less likely to progress since they do not use the technology enough to significantly extend it into their own practices (Moss et al., 2007; Gray, Pilkington, Hagger-Vaughan, & Tomkins, 2007);
- appropriately designing IWT materials that facilitate interaction with the IWB and learning content;
- managing materials in a way that allows all participants an opportunity to interact with the technology and become actively involved in the learning process;
- enhancing the potential of the IWTs by incorporating peripheral hardware (e.g., document cameras, webcams, and clickers) and software (e.g., simulations, 3D content, and dynamic-geometry software) to extend the capabilities of the tool;
- finding and evaluating ready-made digital material that can help aid in the integration of the tool into curricula; and
- integrating different forms of multimedia into IWT lessons by considering issues of pace, cognitive load, and different forms of interactivity (Schmid & Schimmack, 2010).

Professional development opportunities are the key driving forces in the successful integration of any technology. Specific to IWTs, as teachers become more confident with the technical skills and pedagogy inherent to the technology, instruction becomes more engaging and thoughtful. Also, the technology is used as a part of the everyday classroom life, and the investment of the technology is realized. Similarly, teachers begin to move from using the technology as simply a tool to using the technology as an integral part of their instruction to facilitate teaching and learning.

Figure 2-1. Examples of learner response systems. A) Promethean's ActivExpression® and B) ActiVote®, C) SMART's Senteo® and D) Turning Point Response Pad.

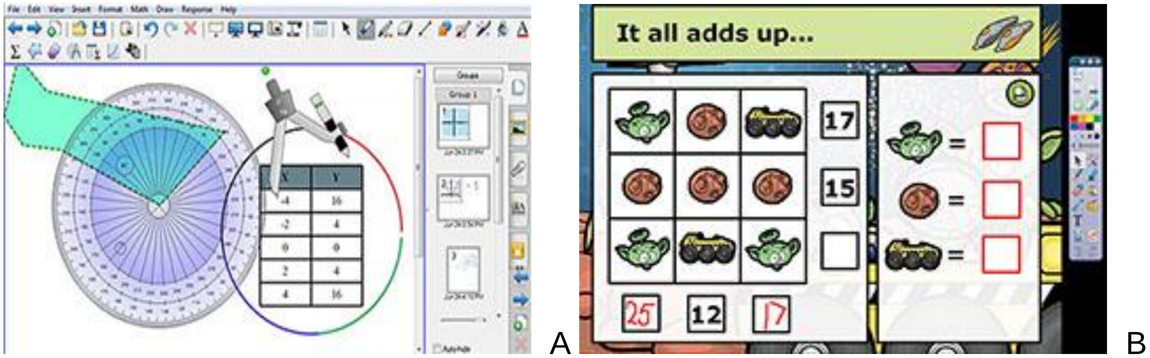


Figure 2-2. Examples of lesson-development software. A) SMART's Notebook® and B) Promethean's ActivInspire®.

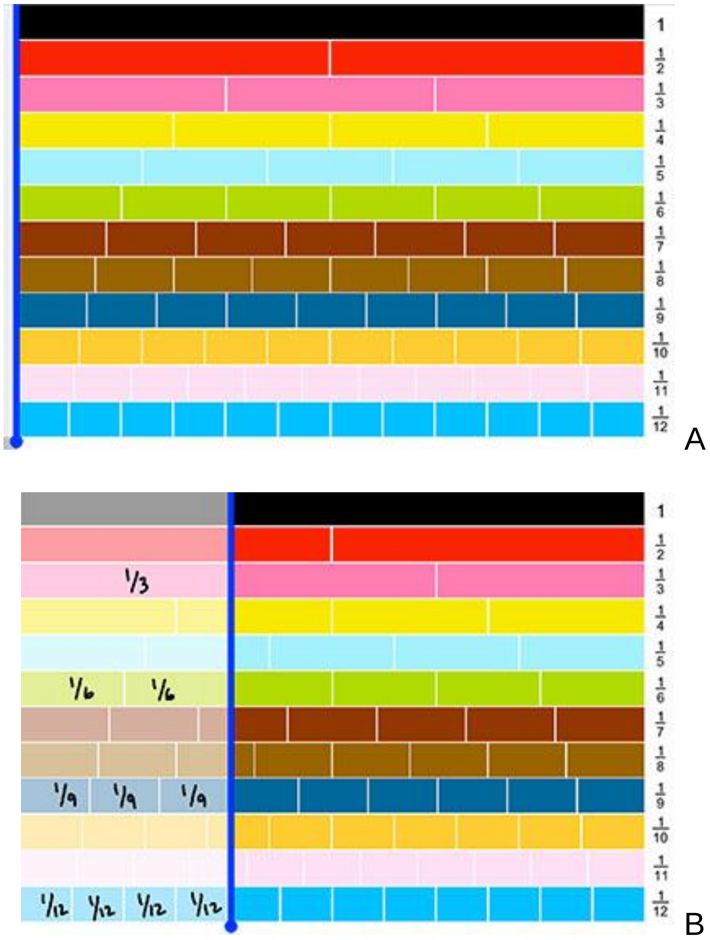


Figure 2-3. Illustration of a “Fraction Wall” using lesson-development software. A) Promthean’s ActivInspire® used to demonstrate equivalent fractions using B) the drag-and-drop manipulation to “drag” the blue line.

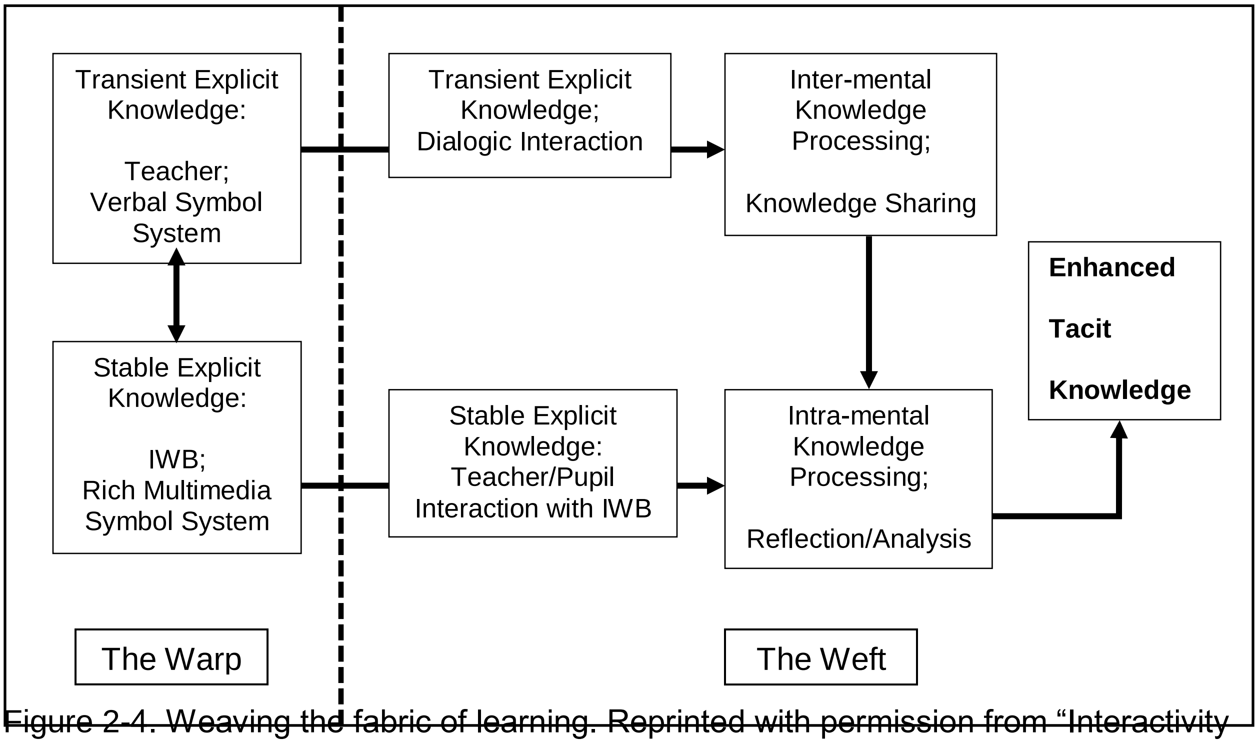
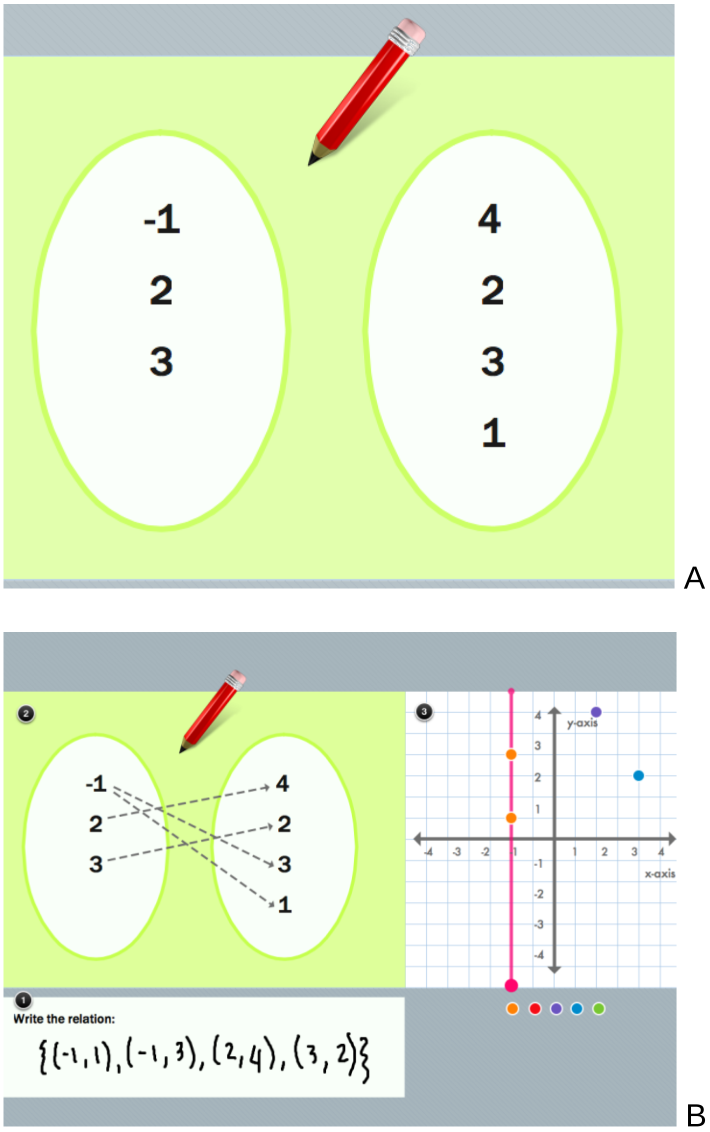


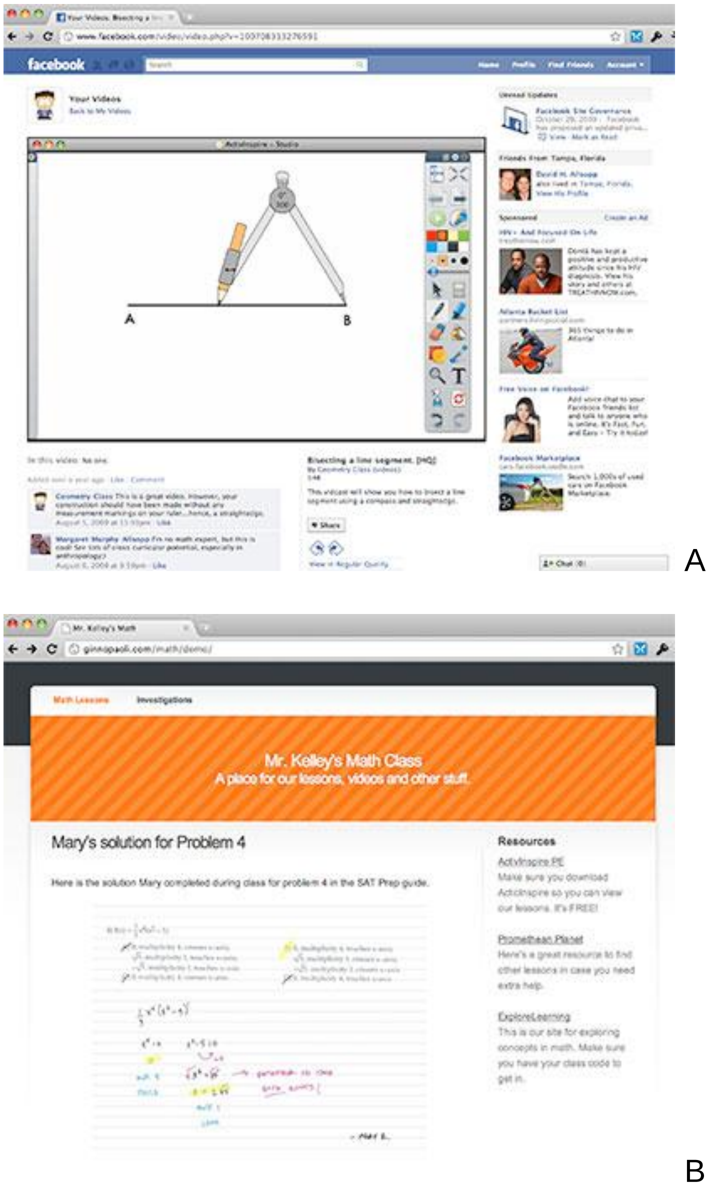
Figure 2-4. Weaving the fabric of learning. Reprinted with permission from "Interactivity and the digital whiteboard: weaving the fabric of learning," by Maureen Haldane, 2007, *Learning, Media and Technology, 32*(3), p.268. Copyright 2007 by Taylor & Francis.



Write the relation:

{(-1,1),(-1,3),(2,4),(3,2)}

Figure 2-5. Examples of multiple representations of functions in a math lesson using IWTs. A) Representation of a relation using a mapping diagram, and B) Three different representations of a relation to help students recognize connections between different ways functions are determined from relations.



Bisecting a line segment. [HQ]

This vidcast will show you how to bisect a line segment using a compass and straightedge.

Mr. Kelley's Math Class

A place for our lessons, videos and other stuff.

Mary's solution for Problem 4

Here is the solution Mary completed during class for problem 4 in the SAT Prep guide.

Resources

ActivInspire PE

Make sure you download ActivInspire so you can view our lessons. It's FREE!

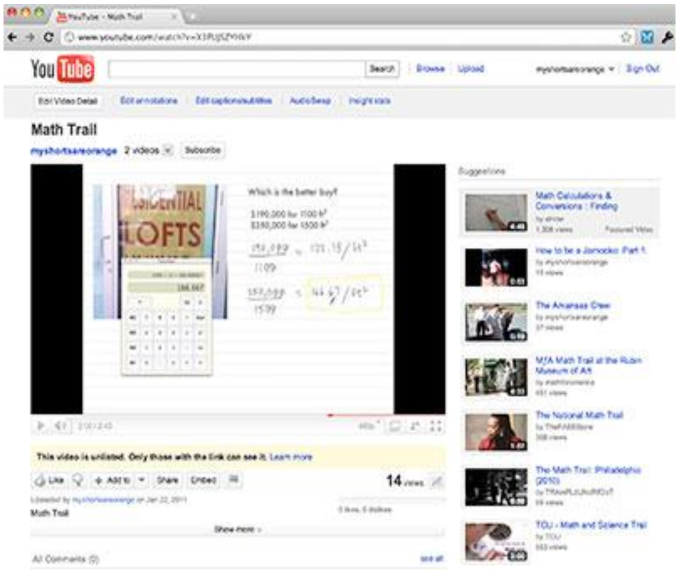
Promethean Planet

Here's a great resource to find other lessons in case you need extra help.

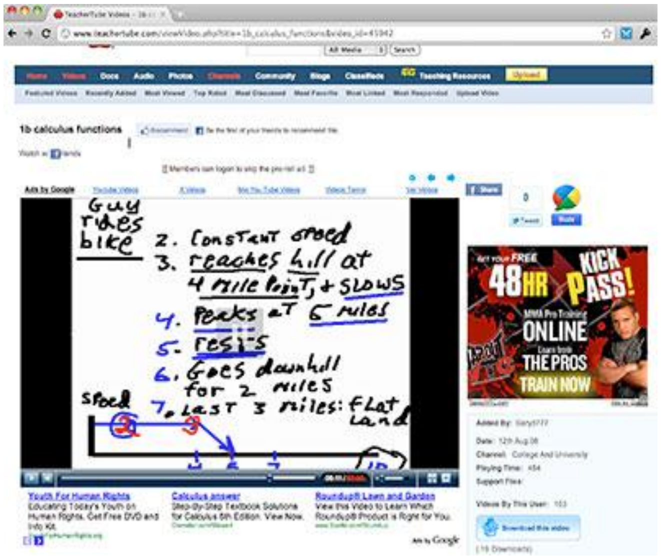
ExploreLearning

This is our site for exploring concepts in math. Make sure you have your class code to get in.

Figure 2-6. Examples of video-embedded teacher content on different websites. A) FaceBook®, B) class website, C) YouTube®, and D) TeacherTube®.



C

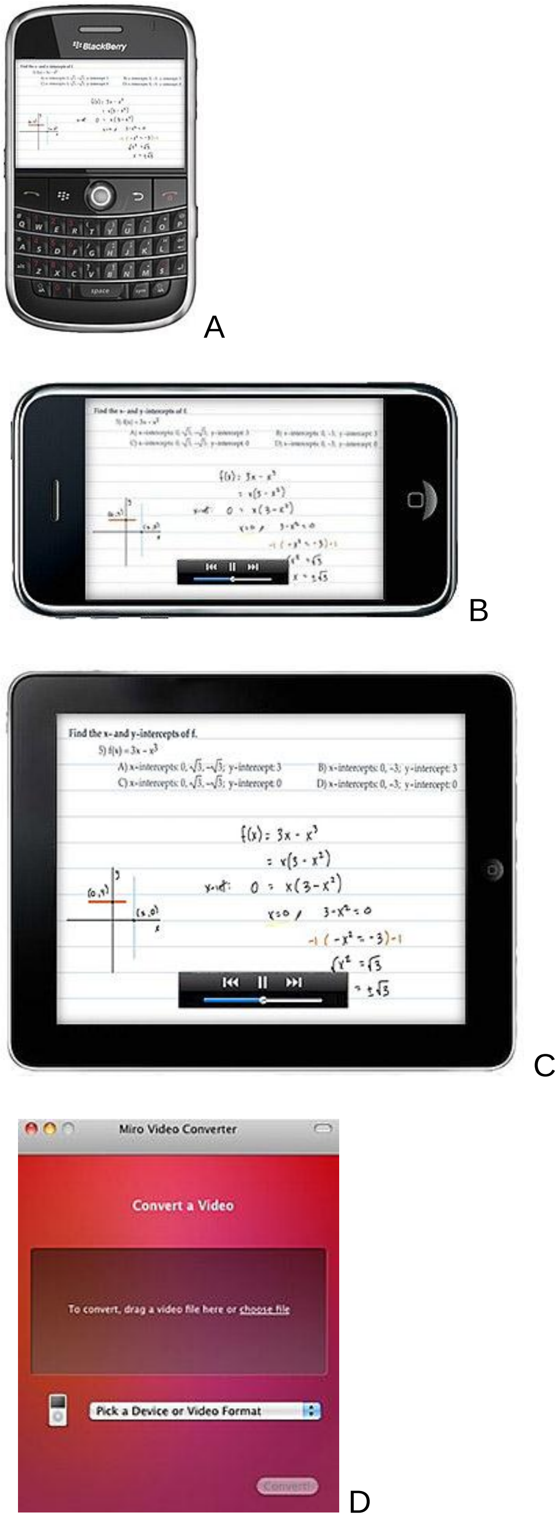


Guy rides bike

2. Constant speed
3. reaches hill at 4 mile point, + slows
4. Peaks at 5 miles
5. rests
6. Goes downhill for 2 miles
7. Last 3 miles: flat land

D

Figure 2-6. Continued.



Find the x- and y-intercepts of f.

5) $f(x) = 3x - x^3$

A) x-intercepts: 0, $\sqrt{3}$, $-\sqrt{3}$; y-intercept: 3

B) x-intercepts: 0, -3; y-intercept: 3

C) x-intercepts: 0, $\sqrt{3}$, $-\sqrt{3}$; y-intercept: 0

D) x-intercepts: 0, -3; y-intercept: 0

Figure 2-7. Examples of how lesson-content can be used on mobile devices. A) iPhone, B) iPad, C) BlackBerry and D) One example of open-source video encoding software, Miro Converter^{TM}.

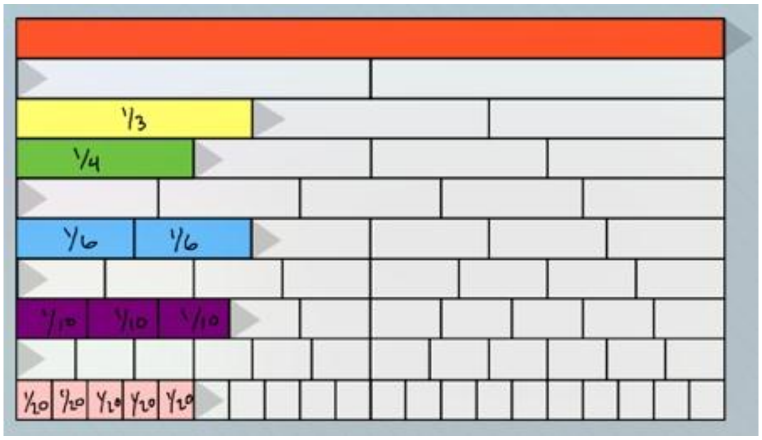


Figure 2-8. Author’s adaptation of lesson on fractions using color shapes to differentiate parts of a whole to the whole.

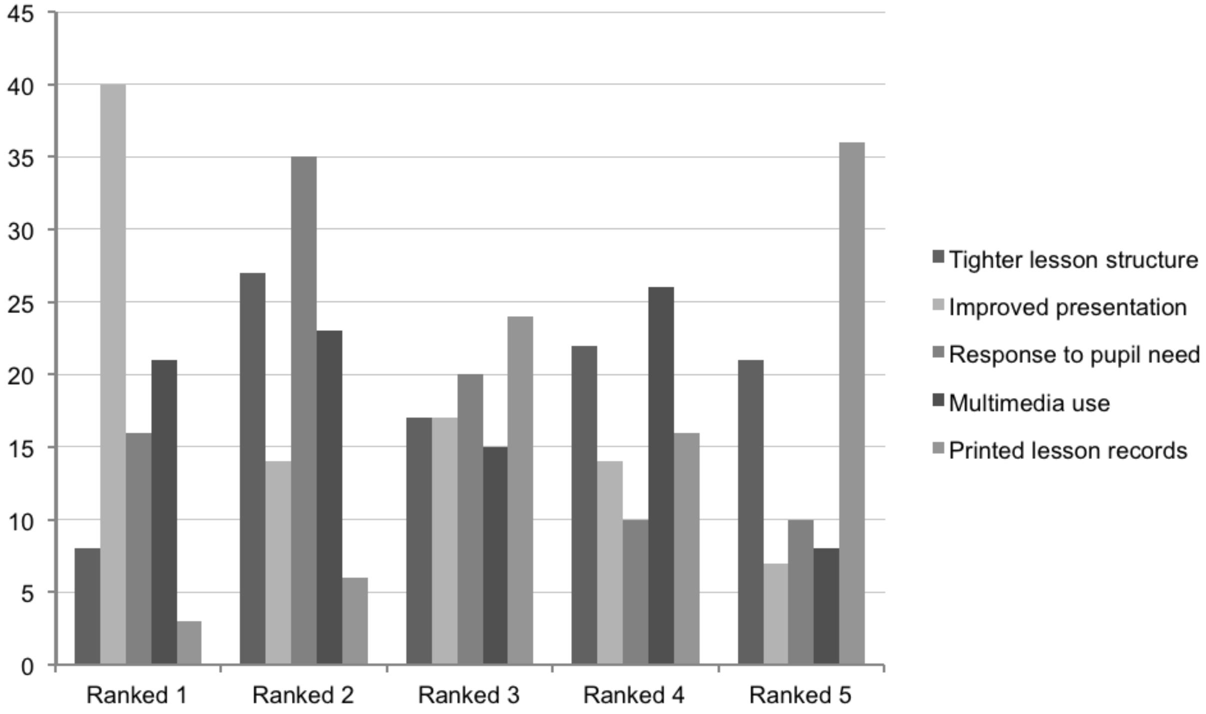


Figure 2-9. The advantages of interactive whiteboards for teaching. Reprinted with permission from “The interactive whiteboard as a force for pedagogic change: The experience of five elementary schools in an English education authority,” by Miller, D. & Glover, D., 2002, *Information Technology in Childhood Education Annual,* 1, pp.5-19. Copyright 2002 by Association for the Advancement of Computing in Education.

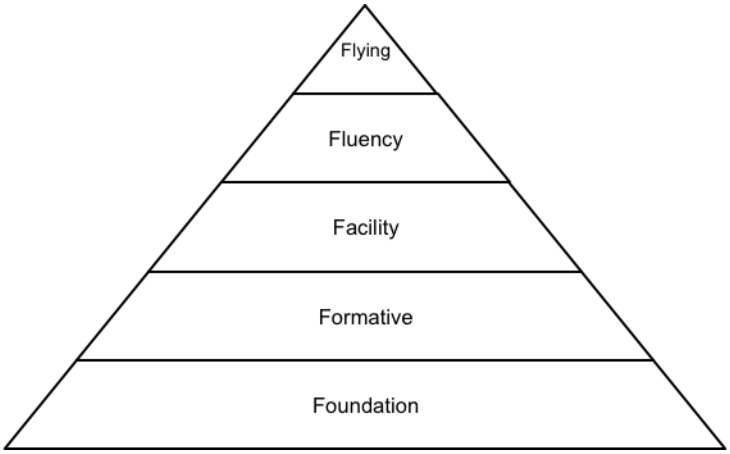


Figure 2-10. A typology of IWT proficiency development. Reprinted with permission from "A new interactive whiteboard pedagogy through transformative personal development," by Maureen Haldane, 2010, *Interactive Whiteboards for Education: Theory, Research and Practice.* IGI Global: Hershey, PA. Copyright 2010 by Information Science Reference.

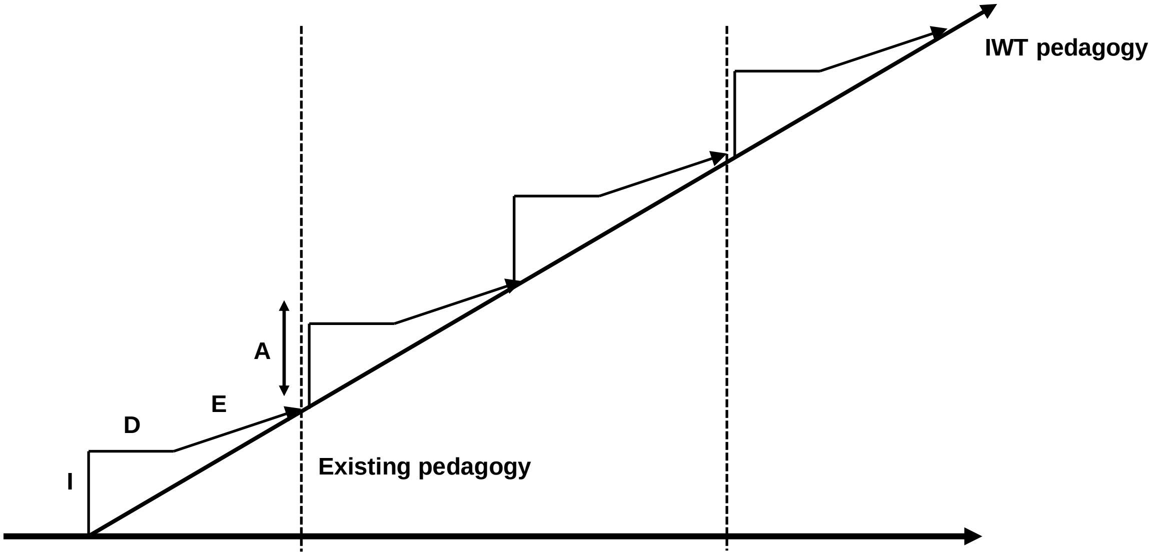


Figure 2-11. The IDEA process: IWT pedagogy emerging over time. Reprinted with permission from "A new interactive whiteboard pedagogy through transformative personal development," by Maureen Haldane, 2010, *Interactive Whiteboards for Education: Theory, Research and Practice.* IGI Global: Hershey, PA. Copyright 2010 by Information Science Reference.

Table 2-1. Constructed features of IWTs that provide potential and structure for classroom activity.

Feature	Meaning
Timeliness	The information available is up-to-date.
Emphasis	Particular items are displayed in a format that highlights them.
Multimodality	The facility to combine visual, aural and textual display.
Accuracy	Items are constructed with greater precision that is realistic manually.
List	The facility to set out a choice of resources or actions.
Template	The provision of a standard outline structure for individuals to add their own ideas.
Acquisition	The entry of data into the IWT device and storage for subsequent processing and display.
Dynamism	Processes and representations can be shown in motion.
Simultaneity	Different processes or forms of display can be shown together.
Library	Data can be stored in an organized way for easy retrieval.
Linkage	Sets of information can be linked for easy access or processing.
Automation	Previously tedious or effortful processes happen automatically (other than changing the form of representation).
Capacity	Storage and retrieval of large amounts of materials.
Range	Access to materials in different forms and from a wider range of sources than otherwise possible.
Provisionality	The facility to change content.
Feedback	The ability to respond to user input contingently.

Note: From “The features of interactive whiteboards and their influence on learning,” by S. Kennewell, and G. Beauchamp, 2007, *Learning, Media and Technology, 32*(3), p. 233. Copyright 2007 by Taylor & Francis.

Table 2-2. Classification of the features of IWTs.

Intrinsic features
Speed (Sp)
Display (Di)
Acquisition (Aq)
Communication (Cm)
Storage (St)
Contingency (Cn)
Repetition (Re)

Features which are constructed	Intrinsic features underlying each constructed feature
Capacity (Ca)	Sp, Cm, St
Range (Ra)	Sp, St
Automation (Au)	Re, Cn, St
Emphasis (Em)	Pa, Di
Template (Te)	St, Aq
List (Ls)	Di Cn, Aq
Provisionality (Pr)	St, Cn, Sp
Timeliness (Ti)	Sp, Cn, St, Cm, Di, Aq
Dynamism (Dy)	Sp, Di, Re, St
Accuracy (Ac)	Sp, St, Di
Simultaneity (Si)	Sp, Di, St
Multimodality (Mu)	Sp, St, Di
Library (Lb)	St, Cn
Linkage (Ln)	St, Au
Feedback (Fe)	Cn, Cm

Actions afforded and constrained	Features contributing potential and structure for each action
Composing	Aq, Te, Ti, Ac
Editing	Pr, Lb
Selecting	Ca Ls, Ln, Lb
Comparing	Si, Mu, Li, Ca
Retrieving	Ra, Au, Ls, Lb, Ln
Apprehending	Ac, Mu, Si
Focusing	Em, Te, Ls
Transforming	Au, Pr, Dy, Mu
Role Playing	Ca, Ra,Te, Ac, Lb Pr, Ti
Collating	Ca, Ra, Lb Lb Si
Sharing	Ra, Te, Pr, Lb
Annotating	Aq, Pr, Ti Em
Revisiting	Au, Lb
Modeling	Au, Te, Pr, Ti, Ac, Ln
Cumulating	Ca, Ln
Undoing	Pr, Au
Questioning	Em, Li, Lb
Prompting	Au, Em, Te, Li
Responding	Fe, Au, Ti, Dy

Note: From “The features of interactive whiteboards and their influence on learning,” by S. Kennewell, and G. Beauchamp, 2007, *Learning, Media and Technology, 32*(3), p. 233. Copyright 2007 by Taylor & Francis.

CHAPTER 3
METHODOLOGY

Technology has become commonplace in schools across the U.S. In a recent teacher survey about perceptions of technology use in the classroom, many teachers reported that a variety of technology devices and Web-based systems can help them do their jobs better and help them engage with students in learning (Grunwald Associates, 2010). Of the teachers surveyed, 68% reported that they value the use of IWTs and consider them to be viable tools in helping them move from traditional pedagogy to a more collaborative culture of learning supported by technology.

Research shows that using IWTs in mathematics instruction has positive effects on students' academic achievement (Cuthell, 2006; Davison & Pratt; 2003; Glover et al, 2003; Hennessy, Deaney, & Ruthven, 2006; Taylor, 1996). Many schools in Florida have IWTs in many or all of their classrooms. Currently, an urban school in central Florida is implementing this type of technology in every classroom. Although research on IWTs and their effect on mathematics instruction is growing, there is a need to continue this research to raise awareness of not only the affordances that these tools can provide, but also how they can impact student achievement in mathematics. As such, this study focused on mathematics instruction and student achievement using IWTs.

This chapter will describe the methodology used for the study. This was a quantitative study, which was conducted using hierarchical linear modeling. The purpose of the study was to determine which factors influence student scores on the Florida Algebra 1 EOC Assessment in four secondary Algebra 1 classrooms using IWTs.

Research Design

When multiple regression models deal with the analysis of data where variables are nested into groups, a hierarchical linear regression model provides a concrete analysis of the data (Goldstein, 1995; Raudenbush & Bryk, 2002). Osborne (2000) suggested that hierarchical data present several problems for analysis. People within existing hierarchies tend to be more similar to each other than those who are randomly sampled from the entire population. Since these individuals tend to share common characteristics, observations from these samples may not be fully independent. This may lead to a null hypothesis if "(a) an appropriate statistical analysis were performed, or (b) the data included truly independent observations" (Osborne, 2008, p. 446). Osborne (2000) also suggested that when the assumption of independence is violated, the regression coefficients can be biased, and the estimates of standard errors are smaller than they should be. Consequently, there is a chance of inferring a relationship as statistically significant when it might have occurred by chance alone. A hierarchical linear model allows for a separate analysis of each level of a hierarchical structure, and the results of the analyses become dependent variables for the next level of a hierarchy, allowing for a more accurate analysis of cross-level interactions.

A hierarchical linear regression model was used to identify factors that influence student scores on the Florida Algebra 1 EOC Assessment. This method of data analysis was selected because it is a flexible way to examine the relationship between a quantitative variable (the dependent variable) and any other factors (expressed as independent variables in different levels). These relationships may be non-linear, the independent variable can be either quantitative or coded, and the effects of a single variable or multiple variables can be examined with or without taking into account the effects of other variables (Cohen, Cohen, West, & Aiken, 2003).

In this study, the two levels observed were the student level (Level 1), which includes student gender and student race/ethnicity, and the teacher level (Level 2), which includes teachers' length of time using IWTs, teachers' levels of interaction using IWTs, years of teaching experience, and the teachers' levels of education. The regression model for Level 1 is:

Level 1

Florida Algebra 1 EOC = $\beta_0 + \beta_1$ * Gender + β_2 * Ethnicity + β_3 * SES + r

where Florida Algebra 1 EOC is the outcome measure, Gender and Ethnicity are the predictor variables, β_0, β_1, $\beta_{2,}$ and β_2 are slopes and intercept estimates separately for each group, and r is the residual.

The regression models for Level 2 are:

Level 2

- $\beta_0 = \gamma_{00} + \gamma_{01}$ * Teacher Time Using Whiteboards + γ_{02} * Teacher Interaction Level + γ_{03} * Teacher Experience + γ_{04} * Teacher Education + u_0
- $\beta_1 = \gamma_{10} + \gamma_{11}$ * Teacher Time Using Whiteboards + γ_{12} * Teacher Interaction Level + γ_{13} * Teacher Experience + γ_{14} * Teacher Education + u_1
- $\beta_2 = \gamma_{20} + \gamma_{21}$ * Teacher Time Using Whiteboards + γ_{22} * Teacher Interaction Level + γ_{23} * Teacher Experience + γ_{24} * Teacher Education + u_2

where Teacher Time Using Whiteboards, Teacher Interaction Level, Teacher Experience, and Teacher Education are group level variables; $\gamma_{00,}$ $\gamma_{10,}$ and γ_{20} are the second stage intercept terms; γ_{01}, γ_{11}, and γ_{21} are the slopes relating Teacher Time Using Whiteboards; γ_{02}, γ_{12}, and γ_{22} are the slopes relating Teacher Interaction Level; γ_{03}, γ_{13}, and γ_{23} are the slopes relating Teacher Experience; γ_{04}, γ_{14}, and γ_{24} are the slopes relating Teacher Education to the intercept and slope terms from the Level 1 equation, and u_0, $u_{1,}$ and u_2 are the Level 2 residuals.

In this study, the dependent variable is student scores on the Algebra 1 Florida EOC exam. There are seven independent variables: Level 1: (1) student gender, (2) student SES, and (3) student race/ethnicity; Level 2: (4) teachers' levels of interaction using IWTs (i.e., supported didactic, interactive, or enhanced interactive), (5) teachers' length of time using IWTs, (6) years of teaching experience, and (7) teachers' education levels.

Population and Sample

The population selected for this study was from one school located within a county in central Florida. According to the county's economic annual report for 2010-2011 (Orange County Government, 2011), the total population was 1,145,956. The county is divided into six districts with the population of the district that contains the school in the study numbering 254,882. The county has experienced a 28% population increase over the last decade, 83% of which was of Latino origin. According to the U.S. Census Bureau (2010), 63.6% of the population was White, 20.8% was Black, and 26.9% were of Hispanic or Latino origin. The remaining percentage of the population consisted of American Indian, Native Hawaiian or Other Pacific Islander, Asian, or those reporting two or more races. Moreover, for the segment of the population older than 25, 9.9% held an associate's degree, 20.8% held a bachelor's degree, 9.6% held a graduate or professional degree, and 19.2% held no degree.

The school is located in a district within the county that has seen substantial growth over the last 5 years. According to the 2010-2011 Florida State Report Card (FLDOE, 2012b), the school had 703 students, with 64% being minority students and

47% classified as free and reduced lunch (FRL). The report card rating for this school during the 2010-2011 school year was a B on a scale from A (highest) to F (failing). This rating is a combination of the Florida Comprehensive Assessment Test (FCAT) scores and learning gains components plus several non-FCAT based components (e.g., graduation rate, graduation rate for at-risk students, postsecondary readiness, and accelerated coursework performance). With respect to mathematics attainment, during the 2010-2011 school year, 77% of students were at or above grade level in math, 78% of students made a year's worth of progress in math, and 66% of struggling students made a year's worth of progress in math (FLDOE, 2012b).

The sample for this study consisted of 328 secondary students taking the Algebra 1 Florida EOC exam. The representative grouping for this study attended the school during the 2010-2011 school year.

Sampling Procedures

The population for this study consisted of four Algebra 1 secondary math teachers and 328 Algebra 1 students in one suburban high school. Purposive sampling was used to identify the teachers and students within the population who met specific criteria. Specifically, the criterion for selection included,

- teachers who had used IWTs for at least 2 years in mathematics,
- teachers with students who took or would take the Florida Algebra 1 EOC Assessment during the 2010-2011 or 2011-2012 school years, and
- teachers who taught Algebra 1 in the identified school for the study.

The rationale for choosing the first criterion is based on research on the typical amount of time it takes for a teacher to become comfortable with the use of IWTs (Cogill, 2010; Haldane, 2010; Marzano & Haystead, 2010). Typically, the first year involves the teacher learning the skill behind each component and learning how it is used from a technical context. The second year is seen as an exploratory year—the teacher begins to become more comfortable with the use of the technology, and the tools become a source of focus. Moreover, 2 years is ample time for the technical hiccups to be addressed when IWTs are implemented into a school district. The second criterion is used since the study examined the factors that influence mathematics instruction as they relate to and are measured by the Florida Algebra 1 EOC Assessment scores. The last criterion specifies the use of teachers who teach Algebra 1 in the identified school since the study focused on one school in one suburban area in central Florida.

Explanation of Variables

Student gender

A large body of literature examines the effects of teacher-student interactions on student and teacher gender (Einarsson & Granström, 2002; Krieg, 2005; Lockheed & Harris, 1984; Massey & Christensen, 1990; Rodriguez, 2002; Sadker, Sadker, & Bauchner, 1984). Research indicates that teachers interact differently with students of the same gender than those of the opposite gender (Etaugh & Hughes, 1975; McCandless, Bush, & Carden, 1976; Rodriguez, 2002). For example, many studies have examined gender differences and suggest, with great controversy, that teachers' attention consistently pointed more toward boys than girls (American Association of University Women, 1992; Kleinfeld, 1998; Lewin, 1998; Sadker, 2002; Sadker & Sadker 1994; Saltzman, 1994; Sommers, 2000); that is, teachers tend to give more positive feedback and attention toward boys. With the nature of high-stakes testing under the NCLB (2002), research that investigates how these interactions impact student achievement is essential. This study investigated student gender as a possible contributing factor in differences in student scores on the Florida Algebra 1 EOC Assessment.

Student race/ethnicity

Research on the impact of student race/ethnicity on student achievement has been well documented (Baker, Keller-Wolff, & Wold-Wendel, 2000; Berends, Lucas, Sullivan, & Briggs, 2005; Kim, 2011; Lee, 2007). The Center on Education Policy (CEP) reported that while students are performing better on state exams, test score gaps between student groups remain large (McMurrer & Kober, 2011). For example, according to the Florida state test-score trends reported by the CEP study, the percentage of all tested high school students who scored at the advanced level in mathematics increased from 35% to 40%, an average gain of 0.7 percentage points per year from 2002 to 2009. The percentage of high school students scoring at the advanced level in mathematics increased from 46% to 52% for White students (the comparison group for gap trends), from 12% to 20% for the African American subgroup, and from 23% to 34% for the Latino subgroup. Although gaps between African American/Latino and White students narrowed slightly in math from 2002 to 2009, there exists a large gap between the numbers of students scoring at the advanced level in mathematics (i.e., White students: 52%, African American students: 20%, and Latino students: 34%). Using student race/ethnicity may provide a clearer picture of the factors that can influence student scores on the Florida Algebra 1 EOC Assessment.

Student socioeconomic status

Poverty (often referred to as *socioeconomic status*) has long been linked to student achievement (Adams, 2004; Cooper, 1998; Grinion, 1999). Research evidence suggests that the social relationships students experience with peers, family members, and adults in the school exert a large influence on student behavior (Harris, 2006). Typically, this process starts with the relationships students have with their parents or primary caregivers that can help define their personalities as either secure and attached or insecure and unattached—securely attached children typically behave better in school (Blair et al., 2008). This process molds students as they progress through school through a progression of socialization that pressures students to be like their peers (or risk social rejection) and to differentiate themselves to higher statuses in several areas, such as sports and personal style. SES plays a large role in this process. Students raised in poverty rarely choose to behave differently, but the challenges they face in comparison to their more affluent peers sometimes undermine good school performance (Jensen, 2009). This study considered SES as an indicator that could potentially affect performance on the Florida Algebra 1 EOC Assessment.

Teacher's level of interaction using IWTs

Glover et al. (2007) established a three-stage framework for identifying the interactivity of effective teaching in mathematics using IWTs. This analysis suggests a teacher's developmental progression (or not) through three stages:

- **Supported didactic**: The teacher makes some use of the IWTs but only as a visual support to the lesson and not as an integral tool. There is little interactivity, student involvement, and discussion; IWTs largely remain a novelty. The IWTs illustrate rather than involve students, and only limited materials are developed with the software or its tools.

- **Interactive**: The teacher makes some use of the potential of the IWTs to stimulate students' feedback and to demonstrate concepts. The teacher invites students to interact with the content at a more cognitive level using a variety of verbal, visual, and aesthetic stimuli. Typically, lessons are made with varied software, and the tools are used to enhance some of the content. However, occasionally, the tool is reverted to being used simply as an illustration tool.

- **Enhanced interactive**: This stage marks a pronounced change in thinking by the teacher, who seeks to make the technology an integral part of most lessons and

> looks for ways of integrating concept and cognitive development by exploiting the interactive capacity of the technology. Teachers at this stage are fluent with the use of the technology and structure their lessons to promote opportunities for student feedback—both individually and in groups—to enhance learning. The tool is used as a means of prompting discourse, explaining processes, and developing hypothesis, effective questioning, and immediate feedback to test student responses.

The researcher used this variable by classifying teachers into one of three groups (i.e., supported didactic, interactive, or enhanced interactive) after conducting two observations per teacher using the observation rubric (Appendix A). This classification was then compared to student scores on the Florida Algebra 1 EOC Assessment to see if the teachers' levels of interaction using IWTs influenced student scores.

Teachers' length of time using IWTs

Many studies report that teachers' length of time using technology is a key contributor to not only how comfortable they are in using the technology, but also how often the technology is used as part of the instruction (Abott & Fouts, 2001; Budin, 1999; Mumtaz, 2000; Redmann & Kotrlik, 2004). Within the context of IWTs, research suggests that teachers who make more use of the affordances of IWTs (i.e., using digital flipcharts and multimedia resources and exploiting the interactive nature of the technology) have a greater impact on student achievement (Allen, 2004; Glover et al., 2005; Hall & Higgins, 2005). Thus, teachers who use the technology more readily in their instruction become more proficient in its use and are able to take full advantage of its affordances. In a recent study by Marzano and Haystead (2010) on the impact of IWTs on student achievement, data suggested that the longer teachers use the technology, the higher the probability of attaining higher learning outcomes for students. In this study, the teachers' length of time (in months) using IWTs was assessed as a possible contributing factor on student scores on the Florida Algebra 1 EOC Assessment.

Years of teaching experience

It has long been assumed that teachers with more years of teaching experience have a greater impact on student achievement. Recent research suggests that this is true—up to a certain point. Studies indicate that the impact of experience is strongest during the first few years of teaching (Clotfelter, Ladd, & Vigdor, 2006; Clotfelter, Ladd, Vigdor, & Wheeler, 2006; Harris & Sass, 2007; Kane, Rockoff, & Staiger, 2006; Ladd, 2008; Sass, 2007). According to a synthesis conducted by Goe (2007) on teacher quality, teaching experience is a qualification that has been shown to have a positive impact on student achievement. Moreover, researchers have found that teaching experience, especially during the first couple of years, is positively associated with student achievement in mathematics and reading (Cavalluzo, 2004; Hanushek, Kain, O'Brien, & Rivkin, 2005; Rockoff, 2004; Rowan, Chaing, & Miller, 1997). This study also looked at years of teaching experience and whether this may contribute to differences in student scores on the Florida Algebra 1 EOC Assessment.

Teachers' levels of education

Research indicates that the effect of teacher education and experience may not be a strong predictor of teacher effectiveness. Several studies suggest that teachers who have completed graduate degrees are not significantly more effective at increasing student learning than those with bachelor's degrees (Harnisch, 1987; Link & Ratledge, 1979; Murnane & Phillips, 1981; Monk, 1994; Summers & Wolfe, 1977). However, other studies state that a teacher's level of education is associated with increased student achievement in particular subject areas, most notably in mathematics.

According to findings in Goe's (2007) synthesis on teacher quality, teachers' knowledge of mathematics matters for student learning in mathematics at all levels, particularly at the secondary level. Specifically, teacher completion of undergraduate and/or graduate majors in mathematics is associated with higher student achievement in middle and high school (Aaronson, Barrow, & Sanders, 2003; Frome, Lasater, & Cooney, 2005; Goldhaber & Brewer, 2000; Monk, 1994; Wenglinsky, 2000, 2002). More recent studies have found marginal benefits for middle school mathematics when teachers hold master's degrees. Moreover, some of these studies indicate that teachers with master's degrees or beyond might negatively influence student achievement (Betts, Zau, & Rice, 2003; Clotfelter, Ladd, & Vigdor, 2006; Monk, 1994; Rowan, Correnti, & Miller, 2002). This study looked at a teacher's level of education as a possible contributing factor to student scores on the Florida Algebra 1 EOC Assessment.

Instrumentation

The school selected to participate in this study had implemented interactive technologies via the use of the IWB, the LRS, and lesson development software over the past 3 years. The scope of this study examined Algebra 1 scores on the Florida EOC Assessment for the participants. The Florida Algebra 1 EOC Assessment analyzed student gender, student race/ethnicity, student SES, amount of time teachers have used IWTs, teachers' levels of education, years of teaching experience, and teachers' levels of interaction using IWTs.

The Florida EOC assessments are part of the Florida's Next Generation Strategic Plan. EOC assessments are computer-based, criterion-referenced assessments that measure the Next Generation Sunshine State Standards (NGSSS) for specific courses (FLDOE, 2012b). Assessments are given in one 160-minute session and contain 35-40 multiple-choice and 20-25 fill-in response items. Students receive a scale score of 325-475; the success of a student on the Florida Algebra 1 EOC Assessment is indicated by achievement levels ranging from 1 (lowest) to 5 (highest). Students with an Achievement Level 3 are classified as having satisfactory performance; scoring at or above Achievement Level 4 indicates the student is high achieving. Table 3-1 provides the scale range for each achievement level. Achievement levels for the Spring 2011 results will not be reported; however, the final score scale and achievement levels for each EOC assessment were established by the State Board of Education in November 2011 for Algebra 1 and will be used in subsequent assessments.

The Achievement Level Policy Definitions, which describe student success with the NGSSS, for the Florida EOC assessments are:

- **Level 5**: Students at this level demonstrate mastery of the most challenging content of the NGSSS.
- **Level 4**: Students at this level demonstrate an above-satisfactory level of success with the challenging content of the NGSSS.
- **Level 3**: Students at this level demonstrate a satisfactory level of success with the challenging content of the NGSSS.
- **Level 2**: Students at this level demonstrate a below-satisfactory level of success with the challenging content of the NGSSS.
- **Level 1**: Students at this level demonstrate an inadequate level of success with the challenging content of the NGSSS (FLDOE, 2012b).

There are three test forms for the Florida Algebra 1 EOC Assessment coded as Form A, B, and C. Each form contains questions common to all three forms and questions unique to each form; field-test questions are also included. All three forms of the 2011 Florida Algebra 1 EOC Assessment contained 54 questions that counted toward student scores (for more information about the test design, see http://fcat.fldoe.org/pdf/designsummary.pdf).

To measure the level of interactivity using IWTs for each teacher, the researcher created a rubric (Appendix A) based on the three-stage typology suggested by Glover et al. (2007). The rubric is divided into the three stages of interactivity: supported didactic, interactive, and enhanced interactive. The three stages are defined as follows:

- **Supported didactic**: In this stage, the teacher uses the IWTs simply for display or visual support for the lesson; the IWTs are not used as an integral part of the content, and there is little interactivity or student input.

- **Interactive**: The teacher begins to incorporate visual, kinesthetic, and verbal stimuli, and the IWTs are mostly used as an integral part of the lesson. The IWTs are no longer seen as a novelty, but rather as a supporting catalyst to learning. However, the IWTs are not fully integrated into the lesson, and their potential is not maximized.

- **Enhanced interactive**: At this stage, the teacher progresses from the interactive level to fully realizing the potential of IWT capabilities. The teacher is fully comfortable exploiting the affordances of the technology in ways that support and enhance the content. Also, the teacher provides opportunities for students to interact with the content both at interface and cognitive levels. Last, the teacher incorporates a wide variety of materials ranging from the Internet to specific software to the LRS.

Glover et al. (2007) segmented these stages further into four contexts based on a strategic planning analytic framework used by Johnson and Scholes (1993). They suggested that four factors determine a framework for *scanning* an environment in which the inherent management of change operates. The four factors are as follows:

- **Pedagogy**: Pedagogy refers to how IWTs are used to support the teaching of the lesson through the use of visual supports, stimulation of content and prompts, explanations, discourse between teacher-student/student-student, and immediate feedback.

- **Engagement (in teaching and learning)**: Engagement refers to how students engage with content at a cognitive level—are students mostly receptors of information with the focus solely on the teacher, or are students encouraged to ask questions, discuss, and develop ideas through out the course of the lesson?

- **Social context**: Social context refers to whether teachers dominate the learning experience—does the teacher direct learning, or are students encouraged to have dialogue with one another? Is the teaching and learning environment one that encourages the active construction on knowledge where students are seen as equal in the learning process?
- **Technology**: How is the technology being used to support teaching and learning? Is the teacher using technology occasionally simply to illustrate concepts, or is the teacher aware of the potential of the technology, and does the teacher use it to stimulate, respond to, and develop ideas for and with students?

Glover et al. (2007) used this framework to code observations of the lesson and the practice within these lessons in order to classify teachers into the three-stage typology. In order to classify the types of interactive behaviors teachers use while teaching the lesson, Glover et al. (2005) identified six manipulations that enhance interactivity in mathematics. These manipulations serve a role in enhancing interactivity between content and learner and help identify teachers along the continuum from supported didactic to enhanced interactive. The six manipulations are:

- **Drag-and-drop**: matching a response to a stimulant and used for classification, matching, processing of data, the creation of questions arising from the dragging and the organization of material
- **Hide-and-reveal**: opening a hidden response when the stimulant was understood and enabling material to be revealed as conceptual development takes place
- **Color, shading, and highlighting**: used for the collection of like terms, enhanced explanation, and analysis through annotation and reinforcement through greater emphasis
- **Matching**: equivalent terms by demonstrating meaning
- **Movement or animation**: used to demonstrate principles and to illustrate explanations.
- **Immediate feedback**: from teacher, pupil, or LRS, sometimes arising from direct consequence of one of the other five methods.

Glover et al. (2005) used these manipulations to help identify how well teachers were integrating the use of IWTs into their teaching and where they fit into the previously mentioned three-stage typology; that is, teachers who used a limited number of manipulations were classified as supported didactic since they were using the technology in a way that did not enhance the content they were teaching; instead, the teachers were merely using the technology as a presentation tool and did little to exploit the affordances of the tool. In contrast, best-practice use of these manipulations included discussion between teacher and student on focused questioning and feedback alongside student annotation of content as teachers explained the process using the IWTs. At this level, the manipulations were used in a way that exploited the affordances of the technology, and teachers began to use the tools to support learning that classified them at the enhanced interactive level.

The researcher used the observation rubric (Appendix A) in the eight (i.e., four Algebra 1 teachers, two observations per teacher) 55-minute lessons, and examples of how teachers were using IWTs were described. First, teachers were observed on what types of manipulations they used, how many they used, and ways in which the manipulations supported the lesson. Second, these manipulations were observed within the four context areas proposed by Johnson and Scholes' (1993) framework, and examples of how they were used were described. Last, these descriptions helped classify teachers as either supported didactic, interactive, or enhanced interactive as suggested by Glover et al. (2007).

The researcher first contacted the school principal to ask for permission to conduct the observations and also to ask for approval from the district office. Next, the researcher contacted each of the participating teachers via e-mail and phone to schedule the observations. Each teacher was given a choice of two lessons for the observation. The only stipulation was that the teachers would use IWTs in some capacity as part of their lessons. This condition helped the researcher collect the necessary data in order to help classify each teacher into one of the three levels of interactivity. Each observation lasted 55 minutes, which is the length of each class period. After the second observation was completed, the researcher asked each teacher to complete the teacher questionnaire (Appendix B). A description of the observation rubric is described below.

The observation rubric consisted of four columns:

1. The *Notes* column was where the researcher recorded the interactions that were observed during the lesson.
2. The *Manipulations used* column was recorded as a series of tick boxes. Underneath each manipulation, there was space to tally how many times the specific manipulation was used during the lesson.
3. The *Teacher-student/student-student interactions* column was used to tally how many times teacher-student/student-student interactions were observed.
4. The *Level of interactivity using IWTs* column was used to circle the level of interactivity for the teacher during that lesson.

The following is a detailed description for each column and how the interactions were recorded:

Notes Column

In this section, the researcher recorded the interactions that were observed during the lesson. The interactions were observed through the context of four themes: pedagogy, engagement (in teaching and learning), social context, and technology. *Pedagogy* is defined as the way in which teachers use IWTs to support content. For example, teachers might use these tools simply as visual supports (e.g., they use the IWB to illustrate a fraction wall but do not use any other supports to promote interactivity) or they might use IWTs to support the teaching of angles by highlighting, shading, or annotating to explain processes, prompt discussions, or develop hypotheses. *Engagement* is defined as how well the teacher uses IWTs to encourage discussion, questioning, and the development of ideas. For example, a teacher might solely use IWTs as presentation tools from which students can copy information, or the teacher might use IWTs to combine different modes of learning like audio, visual, and/or kinesthetic approaches to support the understanding of concepts. *Social context* is defined as the nature of the classroom atmosphere, where the teacher encourages open dialogue, or, conversely, the teacher dominates discourse. For example, a teacher might dominate the classroom and tend to direct the learning, or a teacher might encourage and develop dialogue with students and create an atmosphere where teacher and students learn together. Last, *technology* refers to how well a teacher integrates other technologies alongside IWTs to demonstrate and illustrate concepts. Technology also encompasses how fluent a teacher is in using IWTs to stimulate, respond to, and develop ideas for and with students. Essentially, in the Notes column, the researcher recorded how teachers used IWTs to support the content they were teaching.

Manipulations Column

This section lists the six manipulations that help identify teachers at different levels of interaction based on how they use IWTs to interact with content. These six manipulations are discussed in detail in Chapters 2 and 3. The researcher put a check by each manipulation that was observed throughout the course of a lesson. If the manipulation was used more than once, a tally was kept below each manipulation. For example, a teacher teaching ordered pairs might use highlighting, drag-and-drop, and immediate feedback to show how ordered pairs are plotted on a coordinate plane. First, the teacher might ask students how one might plot an ordered pair (immediate feedback), ask a student to come to the IWB to drag and drop an ordered pair to its correct location on the coordinate plane (drag-and-drop), and, finally, have a student highlight the x-coordinate of the ordered pair (highlighting). Last, the teacher might use the LRS to ask the class if the location of the ordered pair on the coordinate plane is correct (immediate feedback). The researcher recorded this vignette in the Notes column, then ticked the highlighting, drag-and-drop, and immediate feedback checkboxes in this column. Also, since two instances of immediate feedback were used, a tally showing two ticks was marked under the *immediate feedback* response.

Interactions Column

This section was used to tally how many teacher-student/student-student interactions were observed throughout the lesson. A student-student interaction is defined as an interaction (i.e., discussion, dialogue, or explanation) that happens between students relating to the content. These interactions can happen during group work, individual work (e.g., one student helping another), or during the course of an explanation by the teacher or other student. A teacher-student interaction is defined as an interaction (i.e., explanation, discussion, dialogue, questioning, or feedback) that happens between a teacher and student/s. During a teacher-student interaction, the teacher might orchestrate a dialogue with students, simply answer questions that are posed, or engage in discussions in which teacher and student learn together. Each time a teacher-student/student-student interaction occurred, the researcher tallied this section under the appropriate heading.

Level of Interaction Column

This section was used to classify teachers into one of the three levels of interactivity— supported didactic, interactive, or enhanced interactive. The researcher classified teachers into one of the three levels based on the types of interactions observed in the Notes section, the manipulations used and how many times they were used, and the number of teacher-student/student-student interactions (Glover et al., 2007):

- **Supported didactic**: This level is used if the teacher uses IWTs simply as visual supports, and students are largely receptors of information with the focus mostly on the teacher (i.e., there is more than 60% of classroom time spent on teacher-student interactions). This level is characterized by students copying, engaging in conventional board practice, and mostly responding to questions the teacher asks. The teacher at this level uses less that one manipulation to interact with the content on the IWB.

- **Interactive**: This level is used if the teacher uses IWTs to stimulate interest by using demonstrations with lively content (i.e., content may contain multimedia, visuals, and simulations). Students are encouraged to ask questions and discuss and develop ideas when the IWTs are in use, but they become receptors when the focus reverts to the teacher. Teachers at this level encourage and develop dialogue with students and promote discussions, but within conventional frameworks. Teachers use a combination of manipulations to develop ideas, but they have not realized the full potential of the tools. Different manipulations are used throughout the lesson, but their use is intermittent.

- **Enhanced Interactive**: This is the highest level of interaction, and a teacher at this level uses IWTs to prompt, explain, develop, and test concepts throughout the lesson. The pace of lessons is fast, and the teacher elicits feedback from students at regular intervals to assess learning. Students are encouraged to discuss ideas with one another and hypothesize and evaluate content and processes. Also, the teacher develops activities that encourage an active thinking approach. The teacher also uses the affordances of IWTs in ways that help illustrate concepts in different formats. The use of multiple manipulations to interact with content is evident throughout the lesson, and thoughtful consideration is taken to use manipulations that help students learn concepts more clearly.

Since two observations were conducted per teacher, the highest level of interaction observed out of the two was used to classify the teacher.

Data Collection

The researcher requested approval from the district superintendent and the principal for the collection of data. The researcher obtained permission from the district via an Institutional Review Board (IRB) form (Appendix C). The data used for the study included Florida EOC Algebra 1 scores for all students for the 2010-2011school year. The school district's Accountability, Research, and Assessment department provided data in the form of four Excel spreadsheets. Student and teacher identifying information was replaced with assigned numbers to ensure confidentiality.

Two observations per teacher were conducted to assess the teacher's level of interaction using IWTs based on Glover et al.'s (2007) previously described three-stage topology. The researcher used the observation rubric (Appendix A) to classify each teacher into one of the three stages—supported didactic, interactive, or enhanced interactive. Teachers were given the opportunity to select a lesson of their choice for both observations. This method was chosen for two main reasons:

1. Due to the nature of state assessments and because of the timing of the observations during the school year, an unplanned observation may fall on a day where students are testing or the teacher has no formal activity planned.
2. A planned observation gives the teacher the opportunity to select a lesson that best represents the teaching environment.

Student gender, race/ethnicity, and SES were gathered through the school district's student information system (SIS) and were used as the other three independent variables for the study. The teachers' years of teaching experience, length of time using IWTs, and highest level of education were recorded via a questionnaire (Appendix B).

Last, student scores from the Florida Algebra 1 EOC Assessment were used as the dependent variable. The collection of these variables were used in a multiple regression model, specifically a hierarchical regression model, to determine what factors influence student scores on the Florida Algebra 1 EOC Assessment in six secondary Algebra 1 classrooms using IWTs.

Table 3-1. Florida Algebra 1 EOC Assessment Scale Scores (325 to 475)

Level 1	Level 2	Level 3	Level 4	Level 5
325-374	375-398	399-424	425-436	437-475

Note: From *Spring 2012 Algebra 1 End-of-Course (EOC) Assessment Fact Sheet* by Florida Department of Education, 2012. Retrieved on February 4, 2012, from http://fcat.fldoe.org/eoc/pdf/12a1eocfs.pdf

CHAPTER 4
RESULTS

This study examined factors that influenced student scores on the Florida Algebra 1 EOC Assessment in four secondary Algebra 1 classrooms using IWTs. In Chapter 3, the researcher discussed in detail the methodology of the study, including the instrumentation and research design. Data from 2011-2012 academic year of the Florida Algebra 1 EOC Assessment were used, and teacher observations were recorded. Chapter 4 includes the results of the data analysis.

Given the nested nature of the dataset (i.e., students within teachers), the hierarchical linear modeling (HLM) methodology (Raudenbush & Bryk, 1992) was used to analyze the results. Hierarchical data present several problems for analysis; for example, people within existing groups tend to be more similar to each other than those selected randomly from an entire population. Since the people tend to share common characteristics, observations from these samples may not be fully independent. As such, regression coefficients can be biased, and standard errors may be smaller than intended. This may lead into inferring that a relationship is statistically significant when it might have occurred by chance alone. Since HLM allows for a separate analysis at each hierarchical level, a more accurate analysis of cross-level interactions is attained.

As noted earlier, the dataset was nested in nature (i.e., students within teachers), so the first step was to produce the unconditional model (Model A). The unconditional model predicted student scores on the Florida EOC Algebra 1 Assessment. There were no other predictors. The average EOC assessment score for all students was 392.84 points ($t(315) = 149.99$, $p < .0001$).

Model A: Unconditional Model

- Level 1*:*

Florida Algebra 1 EOC = $\beta_0 + \beta_1$ * Gender + β_2 * Ethnicity + β_3 * SES + r

- Level 2*:*
- $\beta_0 = \gamma_{00} + \gamma_{01}$ * Teacher Time Using Whiteboards + γ_{02} * Teacher Interaction Level + γ_{03} * Teacher Experience + γ_{04} * Teacher Education + u_0
- $\beta_1 = \gamma_{10} + \gamma_{11}$ * Teacher Time Using Whiteboards + γ_{12} * Teacher Interaction Level + γ_{13} * Teacher Experience + γ_{14} * Teacher Education + u_1
- $\beta_2 = \gamma_{20} + \gamma_{21}$ * Teacher Time Using Whiteboards + γ_{22} * Teacher Interaction Level + γ_{23} * Teacher Experience + γ_{24} * Teacher Education + u_2

This model provided the results for the analysis described below. Of the six independent variables analyzed, three were statistically significant, namely students' SES, teacher's length of time using IWTs, and teacher's level of interactivity using IWTs (Figures 4-1, 4-2, and 4-3).

Participants

For the academic year 2011-2012, the student sample included 335 secondary students enrolled in Algebra I in one suburban school in central Florida. Table 4-1 displays a summary of the three independent variables used in this study at Level 1 of the analysis: (1) student gender, (2) student SES, and (3) student race/ethnicity. There were a total of 335 students in the sample; however, only 315 were used in the analysis because the remaining students did not take the EOC assessment. There were 271 ninth-grade students, 36 tenth-grade students, seven eleventh-grade students, and one twelfth-grade student. The student sample included 69% low SES, and the total sample consisted of 61% male and 39% female students. Additionally, 2% were identified as Asian, 20% were identified as White, 25% were identified as Black, and 53% were identified as Hispanic.

Students in the sample were taught by one of four Algebra 1 teachers in the same suburban school in central Florida. There were four independent variables used at Level 2 in the analysis related to teacher characteristics: (1) teachers' level of interactivity using IWTs, (2) teachers' length of time using IWTs, (3) years of teaching experience, and (4) teachers' levels of education. Table 4-2 provides a summary of the teacher characteristics used in the sample.

Analysis

A regression analysis was run using SAS software to determine which factors had a potential effect on student scores on the Florida Algebra 1 EOC Assessment. Hierarchical linear modeling was used since the data existed at multiple levels. Specifically, seven variables were used in the analysis—three at the student level (Level 1) and four at the teacher level (Level 2).

Since all four teachers had the same level of education (master's degree), it was determined that this variable would not provide any meaningful insight, and it was not included in the final analysis. As such, a total of six independent variables were included in the final analysis. Table 4-3 provides the results of the analysis. An observation rubric (Appendix A) was used to collect teacher data and to classify each teacher into one of three levels of interaction using IWTs. The researcher scheduled two planned observations with each teacher and used the observation rubric to assess a teacher's level of interaction using IWTs.

The observation protocol is described in detail in Chapter 3, but in summary, in order to classify teachers into one of the three levels of interactivity using IWTs, the researcher first observed the lesson and took notes based on four contexts (pedagogy, engagement, social atmosphere, and technology). As the researcher took notes, he also observed for the types of manipulations, if any, that were used during the lesson. If manipulations were used more than once during the lesson, a tick was recorded underneath each manipulation. The researcher also recorded the number of teacher-student/student-student interactions that were observed during the lesson. The combination of these observed practices provided information that helped classify the teacher into one of the three levels of interactivity using IWTs. The following example summarizes how Teacher A was classified into one of the three levels of interactivity using IWTs in this study.

Teacher A was observed on two different occasions conducting two different lessons. In the first lesson, the teacher directed students to complete a worksheet on solving algebraic word problems individually. There were four instances of teacher-student interaction, whereby the teacher walked by a student and asked if the student had questions on any problems in the worksheet. If the student said *no*, the teacher moved to the next student. If the student said *yes*, the teacher spent some time helping the student, but the discussion was trivial and did not encourage deeper thinking for the understanding of the content. There were also two instances of student-student interaction in which one student asked another student if his answer to a particular problem was correct— but once the question was answered, there was no follow-up discussion. The teacher used the IWB to display directions for the lesson, and no other interactions with the IWTs were observed. A second lesson for Teacher A was also observed, and the teacher in this instance used the IWTs to work through problems presented in the math book on solving multistep equations. The teacher solved each problem, and students copied each problem into their notebooks. On three occasions, the teacher asked the class: (1) “What’s the answer?”, (2) “What do you think goes here?” (pointing to a variable in the equation), and (3) “If I take away three from this side, what do I do to the other side?” In each occasion, either one student answered, or the teacher answered the question directly. After the teacher finished solving the collection of problems, he gave students a worksheet to complete individually. The IWTs were used as a visual support, and one manipulation (feedback) was used on three occasions. Based on the notes, manipulations used, and the number of teacher-student/student-student interactions, Teacher A’s level of interaction using IWTs was classified as supported didactic.

Each of the eight observations used the observation rubric, and teacher questionnaires were completed after the second observation for each teacher. Categorical data from the questionnaire and the teacher’s level of interaction using IWTs from the observation rubric were then converted into numerical data for multilevel analysis. Student demographic data were collected from the district’s SIS and student scores on the Florida Algebra 1 EOC Assessment were collected via the districts and state’s data warehouse.

Results of Analysis

Results of the HLM analyses are provided below. Estimation of the baseline model revealed no significant differences among teachers in the mean of scores of their students, X^2 (3, *n* = 315) = 2.90, *p* =.089. Calculation of the ICC yielded a value of 3.725% based on the unconditional model, which is low but does indicate some level of nesting and, therefore, supports the use of multilevel modeling. According to this model, a score of 368.95 represents the grand mean of students’ scores on the Florida Algebra 1 EOC Assessment. This coefficient has a standard error of 12.96.

Level 1 Variables (Student)

These three variables were gathered through the SIS from the district in the form of Excel spreadsheets. The package contained four spreadsheets, one for each of the four teachers in the study. Each spreadsheet included the student's race/ethnicity, SES, gender, and EOC score. Teacher data from the questionnaire, as well as level of interactivity using IWTs, were appended to each worksheet as separate columns. The four spreadsheets were then combined into one master spreadsheet to ensure student and teacher data were kept in sync. The master spreadsheet was used in the final analysis for multilevel modeling.

Gender

Analysis of student gender showed that male students scored 1.8 points higher on the EOC assessment than female students (Estimate = -1.8034, *SE* = 2.5736, *t*-value = -0.70); however, this was not statistically significant (*p* = .4840). Male students scored an average of 394.75 points (*SE* = 17.4727), and scores ranged between 325 and 435. Female students scored an average of 393.23 points (*SE* = 25.97), and scores ranged between 325 and 466. Figure 4-3 shows the frequency for this variable, and Table 4-4 shows the means of students' scores on the EOC assessment based on gender.

Race/ethnicity

Analysis of student race/ethnicity revealed minority students scoring 0.5 points higher on the EOC assessment than White students (Estimate = 0.4385, *SE* = 3.3229, *t* value= 0.13); however, this was not statistically significant (*p* = .8951). Although this variable was not statistically significant, research shows that minority students generally score lower on mathematics assessments than their White peers (Hemphill & Vanneman, 2011). According to data from 1990-2007 (NCES, 2010), the national gap in average mathematics scores between minority and White students is 31 points. For the state of Florida, the average gap in students' mathematics scores between minorities and White students is 29 points. Figure 4-4 shows the frequencies for this variable, and Table 4-5 shows the means of students' scores on the EOC assessment based on ethnicity.

Socioeconomic status

Student SES was reported using the classification of FRL. The analysis reported students categorized as low SES scored 11 points less than those students categorized as high SES (Estimate = -11.3561, *SE* = 2.8767, *t* value = -3.95). This result was statistically significant ($p < .0001$) and is consistent with national data that show a large gap between average mathematics scores between students who are eligible and not eligible for FRL. According to NCES (2010), students eligible for FRL scored an average of 21 points less in mathematics than students who were not eligible. Figure 4-5 shows the frequencies for this variable, and Table 4-6 shows the means of students' scores on the EOC assessment based on SES.

Level 2 Variables (Teacher)

The teacher variables were gathered through an observation rubric and a teacher questionnaire. The observation rubric was used to classify teachers into one of three levels of interactivity using IWTs. The teacher questionnaire was used to collect data about teacher characteristics, such as years teaching, length of time using IWTs, highest level of education, whether a teacher had a teaching certificate, and the teacher's area of specialization. In this study, one teacher was categorized as supported didactic, two were categorized as interactive, and one was categorized as enhanced interactive.

Length of time using IWTs

Teachers’ length of time using IWTs was reported in ranges of months (0-12, 13-24, 25-36, 37-48, more than 49). Results showed that students scored 6 points less the more experience teachers had in using IWTs (Estimate = -5.5861, *SE* = 2.1883, *t* value = -2.55). This result was statistically significant (*p* = .0112). In contrast, some research (Glasset & Schrum, 2009; Haystead & Marzano, 2010) suggests that teachers who have used IWTs for longer periods of time show an increase in student achievement. Also, as noted in Chapter 3, research suggests that teachers who make more use of the affordances of IWTs have a greater impact on student achievement (Allen, 2004; Glover et al., 2005; Hall & Higgins, 2005).

Years teaching

The number of years the teacher had been teaching was analyzed, and results showed that students scored 0.5 points more the longer the teacher had been teaching (Estimate = 0.5379, *SE* = 0.3083, *t* value = 1.74). This result was not statistically significant (*p* = .0821). Although not statistically significant, this result parallels research suggesting that the impact of a teacher’s years of experience is strongest during the first few years of teaching (Clotfelter, Ladd, & Vigdor, 2006; Clotfelter, Ladd, Vigdor, & Wheeler, 2006; Harris & Sass, 2007; Kane et al., 2006; Ladd, 2008; Sass, 2007); that is, teacher experience is a qualification that has been shown to have a positive impact on student achievement in mathematics, but it is strongest during the first few years of teaching (Cavalluzo, 2004; Goe, 2007; Rockoff, 2004; Rowen et al., 1997).

Level of interactivity using IWTs

Teachers were classified into one of three levels of interactivity using IWTs: supported didactic, interactive, and enhanced interactive. Results showed that students scored 20 points higher as teachers progressed through the levels of interactivity from supported didactic to enhanced interactive; that is, for each level the teacher increased, students' scores increased by 20 points. (Estimate = 19.8694, *SE* = 6.2855, *t* value = 3.16). This result was statistically significant (*p* = .0017). This data paralleled research suggesting that as a teacher's level of interactivity using IWTs increases, student achievement also increases because the teacher is better able to use the affordances of the tool in more robust ways (Glover & Miller, 2007; Miller & Glover, 2010). Table 4-7 shows the mean of students' scores for each teacher's level of interactivity using IWTs.

The teacher questionnaire (Appendix B) also inquired about a teacher's highest level of education, whether the teacher had a teaching certificate, and the teacher's area of specialization. These two independent variables were part of the original analysis; however, all four teachers had the same level of education (master's degree), and all had a valid teaching certificate in Mathematics 9-12. As such, these variables were not included in the analysis since they did not provide additional information.

Summary

Chapter 4 presented statistical results from the study that analyzed factors that influence student scores on the Florida Algebra 1 EOC Assessment. Data analysis was done sequentially and examined the effect of six independent variables on students' scores. Two observations per teacher and a teacher questionnaire were used to collect teacher data. Student data were collected via the district and state's data warehouse. Since the data were nested within teachers, the researcher used hierarchical linear regression to examine the data. The six independent variables existed at two levels: Level 1: (1) student gender, (2) student SES, and (3) student race/ethnicity and Level 2: (4) teachers' levels of interactivity using IWTs, (5) teachers' length of time using IWTs, and (6) years of teaching experience. The dependent variable was the students' score on the Florida Algebra 1 EOC Assessment. Results showed that student gender and race/ethnicity were not statistically significant; however, a student's SES status was statistically significant, yielding an 11-point decrease for students who were identified as low SES. Additionally, a teacher's number of years teaching was not statistically significant; however, a teacher's length of time using IWTs and their levels of interactivity using IWTs were statistically significant. Specifically, students scored 6 points less on the EOC assessment the longer the teacher had been using IWTs. Moreover, students scored 20 points more as the teacher's level of interaction using IWTs increased. The major limitation of the study was the number of teachers used in the sample (discussed in Chapter 3), and this limitation contributed greatly to the final results. The implications, suggestions, and recommendations of the study are discussed in Chapter 5.

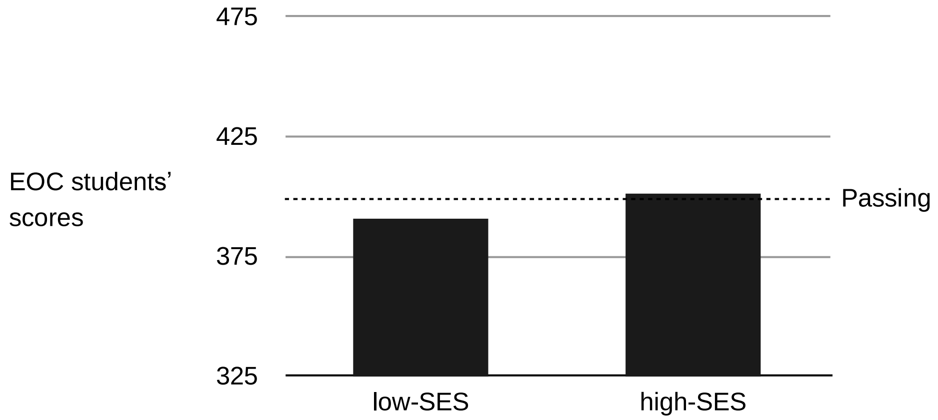


Figure 4-1. Students' mean scores on Florida Algebra 1 EOC Assessment by student's SES (*p* < .0001).

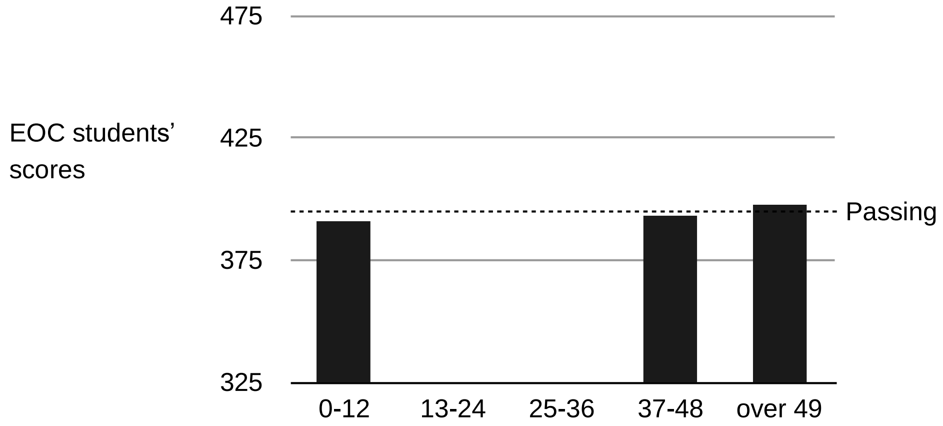


Figure 4-2. Students' mean scores on Florida Algebra 1 EOC Assessment by teacher's length of time (in months) using IWTs (*p* < .0112).

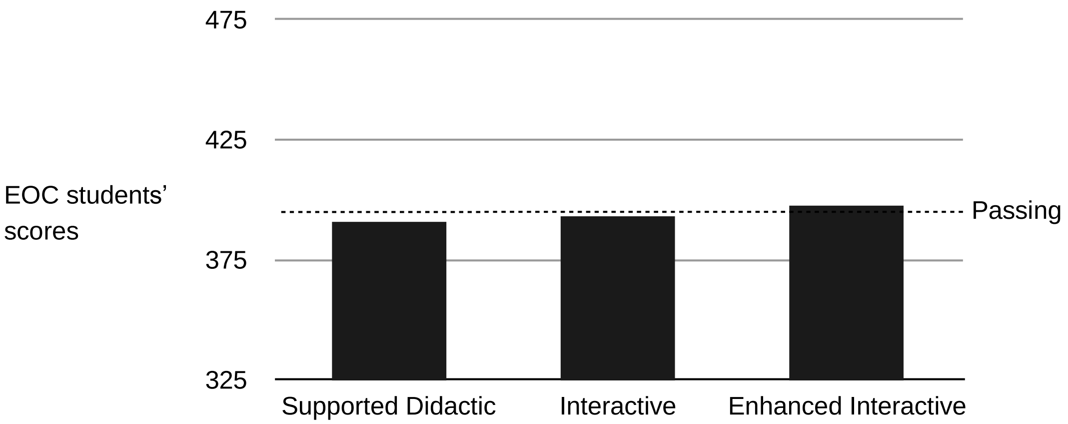


Figure 4-3. Students' mean scores on Florida Algebra 1 EOC Assessment by teacher's level of interactivity using IWTs ($p < .0017$).

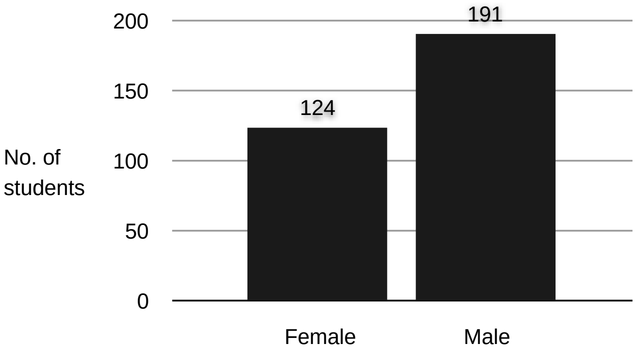


Figure 4-4. Number of students by gender in sample (n = 315).

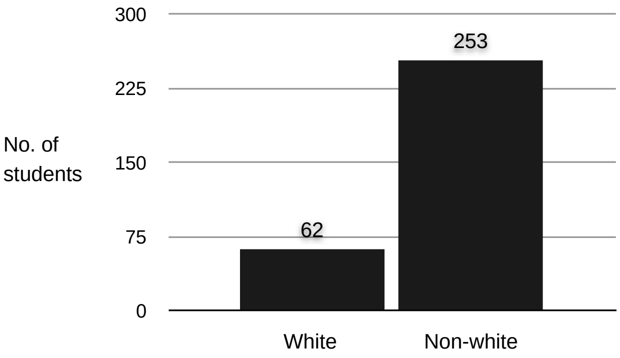


Figure 4-5. Number of students by ethnicity in sample (n = 315).

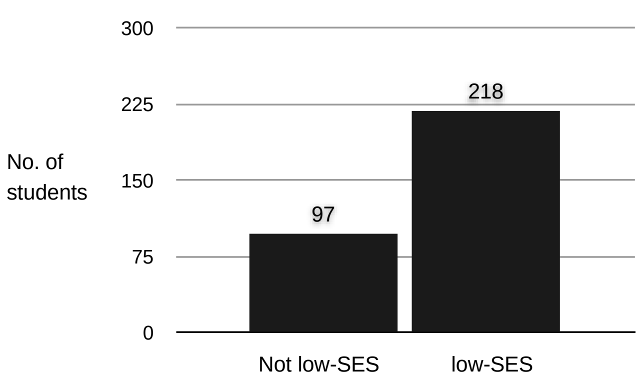


Figure 4-6. Number of students by SES in sample (*n* = 315).

Table 4-1. Summary of student demographics used in sample. A total of 315 students were included in the analysis.

	Asian	White	Hispanic	Black	low-SES	high-SES
No. of students	8	62	166	79	217	98
Percentage (%)	2	20	53	25	69	31

Table 4-2. Summary of teacher characteristics used in sample. A total of four teachers were included in the analysis.

Teacher	Length (in mo.)	Education	Years Teaching	Level
A	0-12	Masters	30	SD
B	13-24	Masters	12	I
C	37-48	Masters	12	I
D	over 49	Masters	12	EI

Abbreviations used in each column: Length refers to the teachers' length of time using IWTs (in months), Education refers to the teachers' level of education, Years Teaching refers to the years of teaching experience and Level refers to the teachers' level of interactivity—SD for Supported Didactic, I for Interactive and EI for Enhanced Interactive.

Table 4-3. Solutions for fixed effects for sample.

Effect	Estimate	Standard Error (SE)	DF	*t* Value	*p*
Intercept	368.95	12.9642	0	28.46	--
Gender	-1.8034	2.5736	308	-0.70	.4840
Ethnicity	0.4385	3.3229	308	0.13	.8951
SES	-11.3561	2.8767	308	-3.95	<.0001
Length	-5.5861	2.1883	308	-2.55	.0112
Years	0.5379	0.3083	308	1.74	.0821
Level	19.8694	6.2855	308	3.16	.0017

Abbreviations used in table: SES refers to socio-economic status, Length refers to the teachers' length of time using IWTs, Years refers to the years of teaching experience and Level refers to the teachers' level of interactivity using IWTs.

Table 4-4. Students' mean scores on EOC assessment by gender.

Gender	N	Mean	SD	Minimum	Maximum
Male	124	394.75	17.47	325	435
Female	191	393.23	25.97	325	466

Table 4-5. Students' mean scores on EOC assessment by ethnicity.

Ethnicity	N	Mean	SD	Minimum	Maximum
White	62	396.48	20.19	325	429
Non-white	253	393.18	23.61	325	466

Table 4-6. Students' mean scores on EOC assessment by SES.

SES	N	Mean	SD	Minimum	Maximum
low-SES	218	390.61	22.92	325	435
high-SES	97	401.05	21.55	325	466

Table 4-7. Students' mean scores on EOC assessment by teacher's level of interactivity using IWTs.

Teacher level of interactivity using IWTs	Mean	SD	Minimum	Maximum
Supported Didactic	390.90	25.90	325	462
Interactive	393.16	24.45	325	435
Enhanced Interactive	397.60	16.57	357	466

CHAPTER 5
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents a summary of the study and important conclusions drawn from the data presented in Chapter 4. It provides a discussion of recommendations and implications for further research into how IWTs may help supplement mathematics instruction in general. In this chapter, the researcher will discuss the following: (a) summary of the statement of the problem and methodology, (b) limitations of the study, (c) discussion of the results of the study and review of the literature, (d) recommendations for future research and for practitioners, and (e) implications for IWTs for mathematics instruction moving forward.

Statement of the Problem and Methodology

Educators, specifically math educators, have been under pressure to raise achievement levels and provide more opportunities for the development of higher order skills. IWTs, a collection of technology tools, have gained acceptance and popularity (Grunwald Associates, 2010). These tools provide teachers with an assortment of affordances that help them create, modify, and expand current curricula in different and meaningful ways. Mathematics instruction can be enhanced through the use of IWTs to support student achievement. As such, the purpose of this study was to determine which factors have an effect on students' scores on the Florida Algebra 1 EOC Assessment in four secondary Algebra 1 classrooms using IWTs.

In order to determine which factors had an effect on students' scores, six independent variables were observed—three student-level variables: (1) student gender, (2) student SES, and (3) student race/ethnicity and three teacher-level variables: (4) teachers' levels of interaction using IWTs, (5) teachers' length of time using IWTs, and (6) teachers' years of teaching experience. Since the variables were nested into two groups (i.e., teacher and student), a hierarchical linear model was used to allow for a more accurate analysis of cross-level interactions. Student-level data were gathered from the district and state's data warehouse, and teacher-level data were gathered through observations and questionnaires. The observations were used to classify teachers into one of three levels of interactivity, and the questionnaires were used to collect teacher characteristics. Data were then converted numerically, and the results were analyzed.

Limitations

It is important to note that the study included some major limitations that were identified before the study was conducted and were solidified after the results were analyzed. One major limitation was the number of teachers used in the study. According to Raudenbush and Bryk (1992), a safe rule of thumb of 10 observations per predictor is necessary for predicting outcomes, specifically for single Level 2 outcomes. Also, in simulation studies, Kreft (1996) suggested that the power of Level 1 effects depends on the total sample size; that is, the total number of observations. Within Level 2 effects, the power is gained by having more groups as opposed to more individuals per group. Generally, if a large number of groups are present, then the number of observations required per group is reduced. Conversely, for a small number of groups, the number of individuals per group should be greater to obtain sufficient power (Hofmann, 1997). Bassiri (1988) found that collecting data over many groups instead of sampling more individuals is preferred for detecting cross-level interactions. Although this study used 315 students in the final analysis, only four teachers were observed, which is lower than the recommended amount. A sample of four teachers is not a sufficient enough number to make conclusions about the larger population. As such, the results of this study are exploratory in nature and not conclusive. However, this limitation points to promising future findings.

The observations for this study were conducted during the latter part of the spring term, when state assessments are usually given. As such, the researcher only had time to observe each teacher in the study a total of two times. Time for conducting the observations was limited because of time conflicts with standardized testing (i.e., FCAT) administered during the same time frame. This major limitation may have influenced the predicted outcomes for detecting cross-level interactions.

This study used extant data and did not include a randomly assigned treatment. As such, the research data were limited to one high school in an suburban school system in central Florida. The quantitative data collection included 335 EOC Algebra 1 standardized test scores, student gender, student SES, student race/ethnicity, teachers' length of time using IWTs, teachers' education levels, and teachers' years of teaching experience.

Teachers who participated in this study were observed in order to classify them into one of three stages of interactivity as proposed by Glover et al. (2007). As such, teachers were given the opportunity to choose two lessons for observation. It may be the case that teachers put their best foot forward during these observations and might not have given the researcher an accurate account of how the lesson was developed.

Since the data were nested into groups, a hierarchical regression model was used. As stated earlier, people within existing hierarchies tend to be more similar to each other than those who are randomly sampled from the entire population. Since these individuals tend to share common characteristics, observations from these samples may not be fully independent (Osborne, 2000); therefore, in order to account for the bias of independence, a hierarchical regression model was used to allow for a separate analysis of each level of a hierarchical structure, and the results of the analyses become dependent variables for the next level of a hierarchy, allowing for a more accurate analysis of cross-level interactions. This study used extant data and did not include a randomly assigned treatment. As such, the research data were limited to one high school in an suburban school system in central Florida.

Another limitation is the use of FRL as a proxy for SES (Harwell & LeBeau, 2010). FRL is one measure of determining a student's SES. Others include ethnicity (Burkhead, Fox, & Holland, 1967), parent income (Worley & Story, 1967), and parent education (Stanfiel, 1973). There are several other factors thought to affect low SES, including nutrition, mobility, parent involvement, and the environment to which students are exposed (DuBois, Felner, Meares, & Krier, 1994; Milne & Plourde, 2006; Sambonmatsu, Kling, Duncan, & Brooks-Gunn, 2007). Moreover, Harwell and Lebeau (2010) cautioned against solely using FRL as a variable to measure a student's SES because (1) educational researchers may be unclear about what the eligibility for FRL does (and does not) represent, (2) FRL possesses several deficiencies that can bias inferences, and (3) FRL is used as a measure of SES despite criticisms of this practice (Hauser, 1994; Kurki, Boyle, & Aladjem, 2005). Central to these concerns is that research often poorly conceptualizes SES and, therefore, may therefore affect the measurement of SES and the interpretation of statistical results (Haug, 1977; Hauser & Warren, 1997; Oakes & Rossi, 2003).

Discussion of Results

In summary, the study included 335 Algebra 1 students and four teachers in one suburban school in central Florida. However, the final analysis only included 315 students since the remaining students did not take the assessment due to being absent. Student data were collected from the district and state's data warehouse, and teacher data were collected from observations and questionnaires. Student and teacher data were analyzed using SAS software. Results of the six independent variables analyzed showed student SES, teachers' length of time using IWTs, and teachers' levels of interaction using IWTs as being statistically significant. Student race/ethnicity, student gender, and a teachers' years of experience were not statistically significant.

Student Race/Ethnicity

Descriptive data revealed that 80% of the student sample was minority (i.e., eight were Asian, 79 were Black, and 166 were Hispanic). The analysis showed that minority students scored 0.4 points higher than White students; however, student race/ethnicity was not statistically significant (p =.8951). As discussed in Chapter 3, research on the impact of student race/ethnicity on student achievement generally reports minority students performing below White students in mathematics (McMurrer & Kober, 2011). Also, according to longitudinal data from the NCES (2010) from 1990-2007, the national gap average between minority and White students is 31 points and 29 points for the state of Florida. Students in the study did not show a significant gap in mathematics scores, and this may be attributed to the school's focus on increasing achievement in mathematics and reading.

The school invested heavily in professional development opportunities for math teachers and training on how to incorporate IWTs into teaching and learning. The principal of the school implemented an expectation for using technology as a key driver in the development of subject matter to help students grasp content in more meaningful ways. Professional development seminars helped the school's math teachers understand how technology can play a purposeful role in curricula. As such, math teachers have been able to use technology in ways that can help students deepen their understanding of mathematical concepts. This focus on helping teachers sharpen their mathematical understanding and educating teachers about how technology can be an integral part of instruction may be a possible reason for a lower-than-expected gap. According to state data for the 2010-2011 school year, 78% of students in this school made a year's worth of progress in mathematics (FLDOE, 2012b).

Even though the achievement gap between minority and White students was less evident in this study, further inquiry is suggested for future studies to determine factors that contributed to this result. For example, it would be interesting to learn whether this result is similar to other schools that have comparable demographics and how IWTs play a role (or not) in the reducing of the achievement gap for the EOC assessment between minority and White students.

Student Socioeconomic Status

In contrast, student SES was a significant ($p < .0001$) factor in students' scores on the EOC assessment. Students classified as low SES scored 11 points lower than higher SES students in the study. Some research found positive outcomes for low SES students in math and science when using technology (Fletcher, 2003; Galuszka, 2007). Interestingly, research on technology and how it affects academic performance in all subjects for low SES students is divided. On the one hand, providing and using technology in purposeful and meaningful ways to enhance instruction can offer disadvantaged students opportunities to enhance their education (Cummins & Sayers, 1995). However, if there is unequal access to the technology, both at school and at home, it may heighten educational stratification (Bolt & Crawford, 2000). The school in this study was one of the early adopters of school-wide IWTs in the district. As part of the principal's initiative for technology integration, each classroom was equipped with IWTs, webcams, computers, and peripherals like digital slates. Also, training on how to use these technologies was a key component of the implementation. Since 47% of students in the school were classified as low SES, school surveys revealed large gaps in at-home technology access and use. As such, school leadership identified technology as playing an important role in the school's curriculum plan to ensure equal access during school hours. The sample for this study showed that 69% of students identified as low SES in Algebra 1 classrooms. Access to technology at home might have been a factor for scoring lower on the EOC assessment since these students might not have had access to technology resources (e.g., computers, Internet, etc.) that could have helped their understanding of the curriculum.

One other explanation for the large percentage of students identified as low SES in Algebra 1 classrooms may be that higher SES students took Algebra 1 in middle school. Students who come from more affluent communities have better access to resources, such as tutors, after school enrichment programs, and more parental involvement. Access to these resources allows them to be better prepared and gives them an advantage in school—in this case, access to resources allows them to progress through mathematics courses at a faster pace (Gamoran & Hannigan, 2000; Loveless, 2008).

Teacher’s Length of Time Using IWTs

A teacher’s length of time using IWTs provided a negative effect on student scores by a margin of 6 points (p = .0112). In other words, as the amount of time a teacher has been using IWTs increases, student scores on the EOC assessment lowered 6 points. This is in contrast with research stating that as a teacher’s length of time using IWTs increases, student achievement also increases (Marzano & Haystead, 2010). This finding is also in contrast with the literature suggesting that teachers who feel more comfortable using IWTs are able to conceptualize the use of the affordances in more robust ways, enabling student achievement to increase (Ekhami, 2002; Higgins, Miller, Smith, & Wall, 2005; Levy, 2002; Mercer et al., 2010; Zevenbergen & Lerman, 2008). Generally speaking, there are several factors that may contribute to a teacher’s use of technology in the classroom. Specifically, there are certain attributes of the teacher that affect if/how technology is used. For example, a teacher’s philosophy may not be compatible with technology (Zhao, Pugh, Sheldon, & Byers, 2002), or adequate access for teacher and students to technology may contribute to how often it is used (Becker & Ravitz, 2001). Moreover, differences between how novice and experienced teachers use technology can also contribute to the quality of technology integration (Meskill, Mossop, DiAngelo, & Pasquate, 2002; Palacio-Cayetano, Schmier, Dexter, & Stevens, 2002). The results of this study differed from the literature in this case. Observations revealed that the teacher who had been teaching the longest (30 years) used the IWTs the least. This teacher was hired midway through the school year and did not receive the training or professional development offered by the school at the beginning of the school year. This might have been a factor in the teacher’s lack of use of the IWTs.

Moreover, some research suggests that teachers with more years of teaching experience tend to use technology less (Ritzhaupt, Dawson, & Cavanaugh, 2012).

Other factors may play a role in this teacher's lack of IWT use. The literature indicates that there exist conditions that are both internal and external that may affect technology use in the classroom. These include characteristics like a teacher's attitude toward technology (Chang & Cheung, 2001; Choi, Choi, Kim, & Yu, 2003; Jeong & Lambert, 2002), its perceived ease of use (Kiraz & Ozdemir, 2006; Klaus, Gyires, & Wen, 2003), and a teacher's pedagogical beliefs (Lim & Chan, 2007). Although this study did not investigate the teacher's perceptions of IWTs, future studies could include teacher interviews that may reveal a teacher's perspective about using technology. Doing this would have helped identify possible reasons for the negative effects in a teacher's length of time using IWTs.

In addition, years of teaching experience had modest effects on student scores—about 0.5 points were gained for every 5 years of teaching experience. This is consistent with recent research indicating that the impact of experience is strongest during the first few years of teaching, but levels off as years progress (Clotfelter, Ladd, & Vigdor, 2006; Clotfelter, Ladd, Vigdor, & Wheeler, 2006; Harris & Sass, 2007; Kane et al., 2006; Ladd, 2008; Sass, 2007).

Teacher's Level of Interactivity Using IWTs

Interestingly, the data revealed that a teacher's level of interactivity using IWTs was the biggest factor in determining student success on the EOC assessment. As teachers progressed through each of the three levels (supported didactic through enhanced interactive), students saw an increase of 20 points respectively (p = .0017). This parallels the findings of Glover et al. (2007) that showed an increase in student participation, engagement, motivation, and achievement as a teacher progresses through the three levels of interactivity using IWTs. Each time the teacher moves on to the subsequent level, new strategies are used and the unique affordances of the IWTs are revealed in more efficient ways.

Observations revealed that the teacher at the supported didactic level spent most of his time sitting at his desk and only used the IWTs for visual support to show the day's assignments. Moreover, students were given a worksheet and asked to complete the worksheet individually. Occasionally, the teacher walked around the room asking students if they needed help. The teacher in this case made very little use of the IWTs or other technologies to support learning. Also, there were minimal teacher-student/student-student interactions, providing students less opportunities for engagement and understanding of the content.

Conversely, teachers at the interactive and enhanced interactive levels used the IWTs to help students interact with content in different ways. For example, one teacher put students in teams of four, and when a problem was shown on the IWB, students worked in teams to find a solution. When a possible solution was reached, students checked with the teacher to make sure they were on the right track. The teacher revealed the different responses and asked students to explain their answers on the IWB. After each team had a chance to explain their answer, the teacher revealed the correct solution. The teacher then used the feedback to keep track of each team's progress. Students were engaged throughout the lesson and were motivated to do their best since they saw this activity as a game of sorts and wanted their team to win.

These two examples show the stark difference between teachers at these different levels. Students who were given a chance to share, discuss, and engage with the content were given more opportunities to deepen their understanding, and, consequently, they performed better on the EOC assessment based on the results of the analysis. At this point, it is important to point out that there is an overarching theme that seems persistent throughout the descriptions of a teacher's level of interactivity using IWTs. Observations from the study suggest that the quality of interactions also depends largely on quality teaching; that is, the teachers who reached the interactive and enhanced interactive levels used effective teaching strategies (e.g., scaffolding, feedback, and pacing) more often and in ways that were enhanced through the use of IWTs. The teacher classified as supported didactic did not use these strategies and, furthermore, reverted to methods consistent with ineffective teaching (e.g., providing little to no support, giving students little to no feedback, and giving students busy work for the majority of the class period).

Recommendations for Future Research

Replicate Study on a Larger Scale

This study was inconclusive because of the sample size. Larger studies should expand the sample size to include multiple schools, grade levels, and subject areas. Having a larger sample size may be useful in identifying other factors that may have an influence on student achievement when using IWTs. For example, the inclusion of multiple schools may help distinguish ways in which suburban and urban schools differ in their use of IWTs. This, in turn, can provide useful information to districts on how to successfully integrate IWTs in their implementation processes. Moreover, including other subject areas may also help identify how IWTs are used to teach different types of content. This may prove useful in determining if IWTs are better equipped at enhancing specific subjects and to what extent. To scale this study, a third level could be added to the model—one that includes analyzing school-level effects. In essence, the model could analyze students nested within teachers nested within schools. Adding this third level in the model may provide a more accurate and robust analysis of cross-level interactions and more precisely determine which factors have the greatest potential for student success on the Florida Algebra 1 EOC Assessment. In addition, future studies should consider including other grade levels to see if a teacher's level of interactivity using IWTs is positively correlated to student achievement. Although this study investigated a small group of variables that may affect student scores, other variables like school climate, teacher professional development opportunities, administration support, and parental involvement may provide additional insights into student achievement using IWTs.

Include IWTs and Non-IWT Classrooms

Future studies should also consider replicating this study to include classrooms that use IWTs and those that do not use IWTs. As noted earlier, results of this study showed a statistically significant difference in student scores as a teacher progressed through the levels of interactivity using IWTs. A deeper analysis of this result reflects that the effect could be a consequence of good teaching and not necessarily the inclusion of using IWTs. The observations revealed that teachers at the interactive and enhanced interactive levels of interactivity used strategies matching good teaching practices, and the teacher at the supported didactic level tended toward traditional methods that have been proved to be not as successful with student learning. Adding a variable to the model that distinguishes teachers who use IWTs and those who do not might provide a clearer picture of whether IWTs make a significant difference on students' scores on the EOC assessment. Additionally, the observation rubric can be used to analyze if certain teaching characteristics and strategies are present in classrooms with IWTs. These results can add to the existing body of knowledge on how IWTs have the potential of improving mathematics instruction.

Include Rich Descriptions of Teacher-Student/Student-Student Interactions

Observations in this study revealed that teachers at the higher levels of interaction were more likely to use teacher-student/student-student interactions as a way to support learning. Recording these types of interactions during the observations only revealed how many times these interactions occurred. Future studies should refine the observation rubric to include rich descriptions of how these interactions developed and descriptions of the types of discussions that ensued. These types of descriptions can provide information on the complexity of the teacher-student/student-student discourse and how it helps students gain a deeper understanding of the content. Furthermore, these descriptions can be used to ascertain the types of questions teachers are asking and how the feedback the teacher is receiving helps guide the course of their instruction. Teacher-student discourse can be captured using a video camera and later transcribed and coded to extract themes that may be common among the teachers who are at the same level of interaction using IWTs. It may also be used to investigate how themes differ between teachers at different levels of interaction using IWTs. Similarly, these themes can also be used as an added element in classifying teachers into one of the three levels of interactivity using IWTs in the observation rubric. Student-student discourse may prove more difficult to capture during the course of a lesson, but a refinement to the observation rubric can include a space for the observer to describe two or three instances of student-student discourse to serve as an example of what happens during the lesson. These descriptions can also be beneficial by describing how the teacher uses the affordances of IWTs coupled with effective questioning to give students opportunities to have deeper discussions and, consequently, deeper understanding about the content.

Future studies could also include student and teacher interviews to attain feedback on the perceptions of the lesson. It would be interesting to understand the teacher's perception of how the lesson evolved throughout the period versus how the researcher coded the observation. This added component can provide a deeper level of understanding for the reasons for including (or not including) particular strategies and a teacher's perception of how IWTs facilitated the delivery of the content. Moreover, student interviews can reveal whether the students feel IWTs added any value to the learning of the content and, if so, in what ways.

Recommendations for Practitioners

IWTs have the ability to enhance mathematics instruction in significant ways. However, simply using the tools as trivial add-ons will not maximize their potential. In order to have meaningful and purposeful integration of the tools, it is imperative to equip teachers with opportunities that allow them to learn the tool from a technical aspect and, more important, from a pedagogical perspective. It is through this lens that the author provides the following recommendations for practitioners.

Technical Proficiency in the Use of IWTs

Practitioners should become technically proficient in the use of IWTs. Often, teachers do not exploit the full capabilities of a tool simply because they do not know what it can do. Learning the technical abilities of a tool can play a crucial role in helping a teacher craft the teaching strategies that can be most effective in different lessons. This is where the three-stage typology for interactivity used in the study may provide some guidance. Teachers, recognizing the level of interactivity to which they belong, could begin to develop their skills using IWTs and increase their technical knowledge in the process. This development is two-fold—as teachers strengthen their technical knowledge of the tool, they also begin to think more deeply about how different teaching strategies can be augmented with the tool. This allows lessons to be crafted in ways that provide learners a myriad of representations of the content that can be manipulated in ways to meet the needs of different styles of learning.

For example, the observation rubric contains a section for tallying the types of manipulations a teacher uses during the course of instruction. The rubric can be used to help teachers better understand the technical affordances of IWTs by focusing on how the manipulations can help augment content. For instance, a teacher in the study at the interactive level used the manipulation of drag-and-drop to show students how to divide polynomials using virtual manipulatives. Researchers of future studies could use this opportunity to reflect with the teacher about how adding a second manipulation (e.g., highlighting) could enhance learning by helping the students cue in on the steps needed to solve the problem. Using the rubric in this way may help teachers become more aware of the technical affordances of IWTs by focusing on the use of manipulations to enhance content.

Expand the Use of the Observation Rubric

The observation rubric in this study was used to classify teachers into one of three levels of interactivity using IWTs. Future studies can expand the use of the observation rubric in a couple of ways. First, teacher evaluators can use the observation rubric as an instrument in determining how well teachers are integrating IWTs into instruction. Data from the observations can help districts craft professional development opportunities in more efficient ways by focusing on a three-tiered approach for integration. This three-tiered approach can parallel the three levels of interactivity using IWTs. Typically, teachers are classified as beginners, intermediate, or advanced in their use of technology depending on how long they have been using the technology. This can often lead to trainings that are not fully compatible with what teachers actually know. The observation rubric can be used in a more robust way by providing rich descriptions of not only how teachers are using IWTs, but also how content is enhanced through different forms of interactions. As such, the rubric can inform professional development more succinctly by targeting the specific needs of teachers based on what is actually happening in the classroom.

The rubric can also be used as a reflection tool for teachers. Teachers can use the rubric to observe other teachers and then use peer collaboration to reflect on ways in which teaching strategies could be augmented with the use of IWTs. The rubric can provide a jumping-off point to explore ideas about how best to integrate IWTs into instruction. One of the key components of using the observation rubric in these ways is providing opportunities for teacher evaluators and teacher training on how to use the rubric. The observation protocol (Appendix A) can be used as a starting point to help observers through the process. Moreover, having multiple observers can help improve inter-rater reliability and help validate the rubric.

Use the Observation Rubric to Inform Content Creation

Identifying specific strategies that can be used to enhance teaching and learning with IWTs can aid in the creation of content. In this case, the observation rubric helped categorize teachers into one of three levels of interactivity. Since the rubric required the observer to provide rich descriptions of classroom activities, data from the observation can be used to help identify how content should be developed to help teachers progress through the three levels of interactivity using IWTs.

To illustrate this point, consider the following vignette: A teacher is teaching a lesson on nutrition, specifically about the sugar content in different drinks. The goal is to have students determine how much sugar is in different types of drinks and how to relate that to healthy living. A teacher at the supported didactic level might begin by asking students a simple question like, “How many teaspoons of sugar are in a 12-oz. can of coke and a 12-oz. can of Mountain Dew$^{©}$?” At this level, the teacher uses the IWTs simply for visual support (Figure 5-1). Also, the questions tend to be low level and are typically answered by the teacher—there is very little teacher-student/student-student discourse.

As a teacher progresses to the interactive level, the affordances of the IWTs are revealed in more creative ways by incorporating a variety of manipulations (discussed in Chapters 2 and 3) that help enhance interactivity. In the previous example, a teacher might have sugar cubes representing a unit of measure for sugar and ask two students to drag and drop the correct number of sugar cubes next to each can on the IWB (Figure 5-2). At the same time, the teacher might start a voting session (feedback manipulation) in which other students in the class can estimate their own predictions for each can and text in their responses. After the feedback has been collected, the teacher unveils the solution by *revealing* the answer under each can using the eraser tool.

A teacher at the enhanced interactive level might take this example further by incorporating the LRS and initiating a self-paced feature that allows questions to be sent to each device. Students, working in pairs, can match a collection of nutritional facts labels to corresponding images of drinks on the IWB (Figure 5-3). As students discuss which labels belong to which drinks, each pair sends feedback to the teacher via the response devices. At this final level, the teacher has given students ownership of the lesson and opportunities to work together to solve a problem.

As demonstrated above, the observation rubric can give content developers data on how to help teachers refine their skills using IWTs. Providing content that matches the level of interactivity can help teachers become more comfortable in the use of the technology. Additionally, it can provide teachers an easy and safe way to use IWTs through methods that promote deeper understanding of content by learning how best to use IWTs in ways that augment instruction.

Implications for IWTs

This study provided insights into factors that influence student scores on the Florida Algebra 1 EOC Assessment in secondary Algebra 1 classrooms that use IWTs. However, the study has implications for more widespread applications of IWT use in teaching and learning. From a pedagogical perspective, IWTs can be utilized to foster critical thinking through rich teacher-student/student-student interactions to expose students to various ways of thinking. These interactions may include exploration and inquiry that tap into students’ prior knowledge and build a classroom atmosphere where teacher and student work together in the co-construction of knowledge. In this study, this was most evident in observations of the teacher categorized at the enhanced interactive level. Future studies can specifically include classrooms that use learner response devices as an integral part of the lesson. The observation rubric can then be augmented to provide space for the description of how these devices are used in the classroom to help facilitate teacher-student/student-student interactions.

Research shows that IWTs engage and motivate students by providing a more robust way of representing content (Beeland, 2002; Miller & Glover, 2011; Smith et al., 2006), and this has implications for secondary students. Secondary students are sometimes hard to engage because, often, there exists a disconnect between how they learn in school and how they learn outside of school. Specifically, technology plays a large role in how they communicate and socialize and has become an integral part of their personal lives. As such, students often become more easily bored and distracted using traditional classroom tools. IWTs can help mitigate this gap due to their capacity to engage students by making it easier to connect to the real world through the use of simulations and third-party software (e.g., Google Earth©), which can be manipulated and explored using IWTs. Additionally, getting students to engage in dialogue can prove difficult in secondary classrooms due to peer pressure, pace of lessons, or a student's fear of failure. Consequently, it can sometimes be difficult to capture in-the-moment feedback that can contain valuable information for teachers. However, IWTs give teachers the opportunity to capture this feedback easily and efficiently and give the teacher data that can help guide the course of their instruction in more informed ways. The teacher classified as supported didactic in this study had little student-student interaction as part of instruction. Identifying this teacher at an early stage during the year using the observation rubric can result in interventions that can help foster better use of the IWTs. That is, as a teacher is classified at the lower level of interaction, teachers at higher levels can work with their peers to better showcase the affordances of IWTs and how these tools can be better integrated into the curriculum.

Conclusion

This study has informed the researcher in numerous ways on how mathematics instruction can benefit from the use of IWTs to enhance student achievement. For example, this study has provided the researcher with an in-depth understanding of how IWTs can enhance mathematics instruction in meaningful and purposeful ways. Also, it has provided a starting point for replicating studies like this on a larger scale, which can help educators understand how teaching and learning is best supported with the use of IWTs in other content areas through the use of the observation rubric. Most important, this study has provided insight into helping teachers and administrators take a more critical look at how mathematics instruction is supported through the use of IWTs to promote student achievement by providing a method for classifying teachers into levels of interaction using IWTs.

Specifically, the research conducted in this study provided some useful understandings into factors that had an effect on students' scores on the Florida Algebra 1 EOC Assessment in classrooms using IWTs. The results highlighted features that can positively impact mathematics achievement when considered holistically using IWTs; that is, IWTs are most effective when they are used not as a supplement to instruction, but rather as an integral part of everyday classroom life. The research also indicated that IWTs, in and of themselves, are not a remedy for improving student achievement in mathematics; rather, it is the combination of a teacher's strategies and instructional methods coupled with maximizing the affordances of IWTs that provide the greatest impact on student achievement. IWTs are not the cure-all in terms of student achievement in mathematics; however, these tools can offer teachers different avenues for exploring new and exciting ways of representing content to help foster deeper understanding of mathematical content. Last, the observation rubric used in this study can aid practitioners in the development of content, provide better insight into how IWTs are best integrated into curricula, and demonstrate how rich teacher-student/student-student interactions can help foster deeper understanding of mathematical content.

How many teaspoons of sugar are in each can?

Your Name____________

Your Name ____________

Total: ________

1 cube = 1 tsp

Total: ________

Figure 5-1. Example nutrition lesson on sugar content of different drinks.

How many teapoons of sugar are in each can?

Your Name Mara

Your Name John

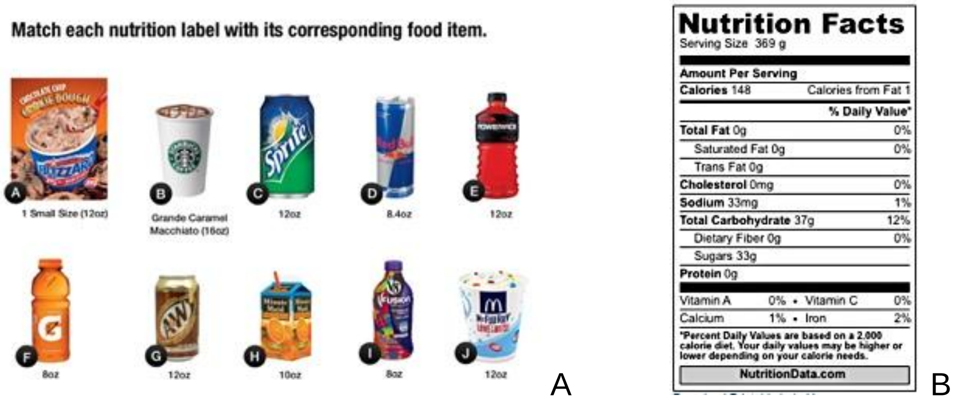
10 tsp

Total: 7

1 cube = 1 tsp

Total: 10

Figure 5-2. Example of using drag-and-drop manipulation on nutrition lesson.



Match each nutrition label with its corresponding food item.

Nutrition Facts
Serving Size 369 g

Amount Per Serving
Calories 148 Calories from Fat 1
% Daily Value*
Total Fat 0g 0%
Saturated Fat 0g 0%
Trans Fat 0g
Cholesterol 0mg 0%
Sodium 33mg 1%
Total Carbohydrate 37g 12%
Dietary Fiber 0g 0%
Sugars 33g
Protein 0g
Vitamin A 0% • Vitamin C 0%
Calcium 1% • Iron 2%
*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.
NutritionData.com

Figure 5-3. Nutrition lesson continued, A) matching different drinks to the nutritional labels B) using sugar content and serving size on labels using learner response systems

APPENDIX A
OBSERVATION RUBRIC AND PROTOCOL

The following observation protocol was used for each of the eight observations (2 per teacher) for this study. The researcher contacted the principal to ask for permission to conduct the observations and also asked for approval from the district office. Next, the researcher contacted each of the participating teachers either through email or phone to schedule the observations. Each teacher was given the option to choose two lessons of their choice for the observation. The only stipulation was that the teachers were using IWTs as part of their lesson in some capacity. This condition helped the researcher collect the necessary data in order to help classify each teacher into one of the three levels of interactivity. Each observation lasted 55 minutes, which is the length of each class period. After the second observation was completed, the researcher asked each teacher to complete the teacher questionnaire (see Appendix B).

Each observation used an observation rubric (see below). The observation rubric consisted of four columns:

1. The *Notes* column was where the researcher recorded the interactions that were observed during the lesson.
2. The *Manipulations used* column was recorded as a series of tick boxes. Underneath each manipulation, there was space to tally how many times the specific manipulation was used during the lesson.
3. The *Teacher-student/student-student interactions* column was used to tally how many times teacher-student/student-student interactions were observed.
4. The *Level of interactivity using IWTs* column was used to circle the level of interactivity for the teacher during that lesson.

The following is a detailed description for each column and how the interactions were recorded:

Notes Column

In this section, the researcher recorded the interactions that were observed during the lesson. The interactions were observed through the context of four themes: pedagogy, engagement (in teaching and learning), social context, and technology. *Pedagogy* is defined as the way in which teachers use IWTs to support content. For example, teachers might use these tools simply as visual supports (e.g., they use the IWB to illustrate a fraction wall but do not use any other supports to promote interactivity) or they might use IWTs to support the teaching of angles by highlighting, shading, or annotating to explain processes, prompt discussions, or develop hypotheses. *Engagement* is defined as how well the teacher uses IWTs to encourage discussion, questioning, and the development of ideas. For example, a teacher might solely use IWTs as presentation tools from which students can copy information, or the teacher might use IWTs to combine different modes of learning like audio, visual, and/or kinesthetic approaches to support the understanding of concepts. *Social context* is defined as the nature of the classroom atmosphere, where the teacher encourages open dialogue, or, conversely, the teacher dominates discourse. For example, a teacher might dominate the classroom and tend to direct the learning, or a teacher might encourage and develop dialogue with students and create an atmosphere where teacher and students learn together. Last, *technology* refers to how well a teacher integrates other technologies alongside IWTs to demonstrate and illustrate concepts. Technology also encompasses how fluent a teacher is in using IWTs to stimulate, respond to, and develop ideas for and with students. Essentially, in the Notes column, the researcher recorded how teachers used IWTs to support the content they were teaching.

Manipulations Column

This section lists the six manipulations that help identify teachers at different levels of interaction based on how they use IWTs to interact with content. These six manipulations are discussed in detail in Chapters 2 and 3. The researcher put a check by each manipulation that was observed throughout the course of a lesson. If the manipulation was used more than once, a tally was kept below each manipulation. For example, a teacher teaching ordered pairs might use highlighting, drag-and-drop, and immediate feedback to show how ordered pairs are plotted on a coordinate plane. First, the teacher might ask students how one might plot an ordered pair (immediate feedback), ask a student to come to the IWB to drag and drop an ordered pair to its correct location on the coordinate plane (drag-and-drop), and, finally, have a student highlight the x-coordinate of the ordered pair (highlighting). Last, the teacher might use the LRS to ask the class if the location of the ordered pair on the coordinate plane is correct (immediate feedback). The researcher recorded this vignette in the Notes column, then ticked the highlighting, drag-and-drop, and immediate feedback checkboxes in this column. Also, since two instances of immediate feedback were used, a tally showing two ticks was marked under the *immediate feedback* response.

Interactions Column

This section was used to tally how many teacher-student/student-student interactions were observed throughout the lesson. A student-student interaction is defined as an interaction (i.e., discussion, dialogue, or explanation) that happens between students relating to the content. These interactions can happen during group work, individual work (e.g., one student helping another), or during the course of an explanation by the teacher or other student. A teacher-student interaction is defined as an interaction (i.e., explanation, discussion, dialogue, questioning, or feedback) that happens between a teacher and student/s. During a teacher-student interaction, the teacher might orchestrate a dialogue with students, simply answer questions that are posed, or engage in discussions in which teacher and student learn together. Each time a teacher-student/student-student interaction occurred, the researcher tallied this section under the appropriate heading.

Level of Interaction Column

This section was used to classify teachers into one of the three levels of interactivity— supported didactic, interactive, or enhanced interactive. The researcher classified teachers into one of the three levels based on the types of interactions observed in the Notes section, the manipulations used and how many times they were used, and the number of teacher-student/student-student interactions (Glover et al., 2007):

- **Supported didactic**: This level is used if the teacher uses IWTs simply as visual supports, and students are largely receptors of information with the focus mostly on the teacher (i.e., there is more than 60% of classroom time spent on teacher-student interactions). This level is characterized by students copying, engaging in conventional board practice, and mostly responding to questions the teacher asks. The teacher at this level uses less that one manipulation to interact with the content on the IWB.

- **Interactive**: This level is used if the teacher uses IWTs to stimulate interest by using demonstrations with lively content (i.e., content may contain multimedia, visuals, and simulations). Students are encouraged to ask questions and discuss and develop ideas when the IWTs are in use, but they become receptors when the focus reverts to the teacher. Teachers at this level encourage and develop dialogue with students and promote discussions, but within conventional frameworks. Teachers use a combination of manipulations to develop ideas, but they have not realized the full potential of the tools. Different manipulations are used throughout the lesson, but their use is intermittent.

- **Enhanced Interactive**: This is the highest level of interaction, and a teacher at this level uses IWTs to prompt, explain, develop, and test concepts throughout the lesson. The pace of lessons is fast, and the teacher elicits feedback from

> students at regular intervals to assess learning. Students are encouraged to discuss ideas with one another and hypothesize and evaluate content and processes. Also, the teacher develops activities that encourage an active thinking approach. The teacher also uses the affordances of IWTs in ways that help illustrate concepts in different formats. The use of multiple manipulations to interact with content is evident throughout the lesson, and thoughtful consideration is taken to use manipulations that help students learn concepts more clearly.

Since two observations were conducted per teacher, the highest level of interaction observed out of the two was used to classify the teacher.

Observation Rubric

Teacher Name:
No. of students:
Lesson Duration:

Date:
Observation (1/2):
Lesson Topic:

Notes	Manipulations Used (Check all that apply and tally number of times used)	Student-Student/Student-Teacher Interaction (Tally)	Level of Interactivity (Circle Highest Level Observed)
	☐ Drag-and-drop ☐ Hide-and-reveal ☐ Color, shading, highlighting ☐ Matching ☐ Movement or animation ☐ Immediate Feedback	Student-Student Teacher-Student	Supported Didactic Interactive Enhanced Interactive

Example Observation Rubric

Teacher Name: Mary Jane
No. of students: 28
Lesson Duration: 55 minutes

Date: May, 1, 2012
Observation (1/2): 1
Lesson Topic: Slope-Intercept Form

Notes	Manipulations Used (Check all that apply and tally number of times used)	Student-Student/Student-Teacher Interaction (Tally)	Level of Interactivity (Circle Highest Level Observed)
• Teacher used IWB as visual support and occasionally demonstrated ExploreMath Gizmo to show relationship between slope and y-intercepts. • Students largely receptors of information with focus on teacher (30 minutes). However, teacher occasionally encouraged students to question and discuss when demonstrating on IWB (3 times during the lesson). Discussion focused on surface-level questioning (e.g., “Where does this line cross the y-axis?”; “Looking at the slop-intercept form of this equation, what is the slope?”). • Student-teacher interactions were focused on getting one-on-one help when students were doing classwork. Classwork consisted of doing problem sets from the course textbook. • Teacher uses conventional framework for student-student dialogue, namely, work in pairs to find a solution to a problem posed on the IWB. Teacher then asked one pair of students to come to the board and work out the solution. Other students sat and watched the IWB with little to no interaction. Teacher then revealed the correct answer without much input from students. This happened 3 times for 3 problems with 3 pairs of students. • Teacher used other technology tools (ExploreMath Gizmo’s) to illustrate the relationship between slopes and intercept using the IWB. Teacher did not make use of the clickers during the lesson.	☐ Drag-and-drop IIIII II ☐ Hide-and-reveal II ☐ Color, shading, highlighting IIIII III ☐ Matching ☐ Movement or animation ☐ Immediate Feedback IIII	Student-Student IIIII II Teacher-Student IIII	Supported Didactic [✓ Interactive] Enhanced Interactive

APPENDIX B
TEACHER QUESTIONNAIRE

Teacher Name:

Years Teaching (in years):

Length of time using interactive whiteboard tools (in months):
A. 0-12 months
B. 13-24 months
C. 25-36 months
D. 37-48 months
E. over 49 months

If choice E, how many months total:

Highest level of education and major:
A. Bachelor's Degree
B. Master's Degree
C. Specialist Degree
D. Doctorate Degree

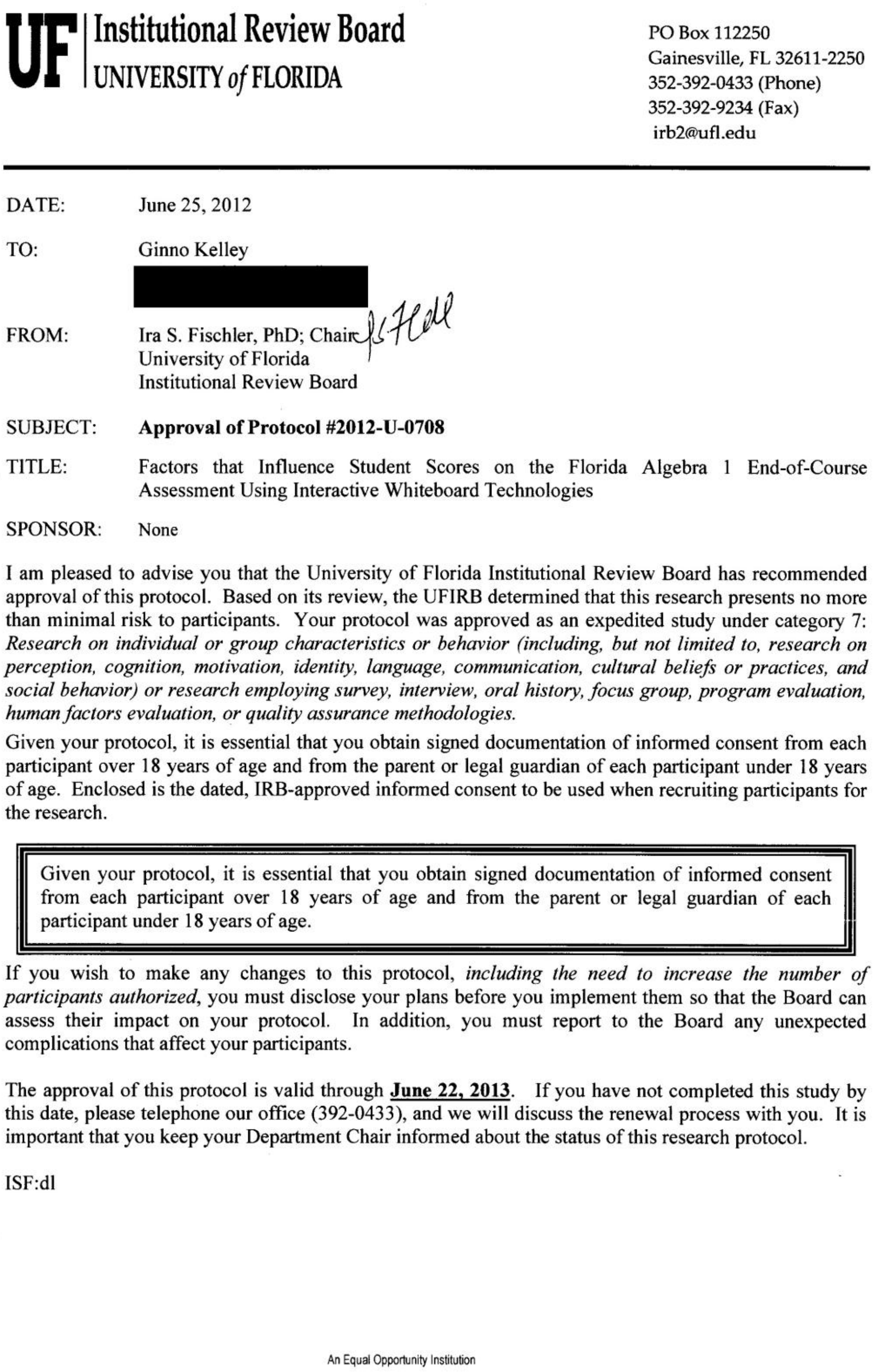
Major:

Do you have a mathematics teaching certificate?
A. Yes
B. No

If yes, from where?

In what area(s) of mathematics are you certified?
A. Mathematics Pre-K
B. Elementary Mathematics
C. Mathematics 9-12

APPENDIX C
IRB PERMISSION



UF | Institutional Review Board
UNIVERSITY *of* FLORIDA

PO Box 112250
Gainesville, FL 32611-2250
352-392-0433 (Phone)
352-392-9234 (Fax)
irb2@ufl.edu

DATE: June 25, 2012

TO: Ginno Kelley
[redacted]

FROM: Ira S. Fischler, PhD; Chair
University of Florida
Institutional Review Board

SUBJECT: **Approval of Protocol #2012-U-0708**

TITLE: Factors that Influence Student Scores on the Florida Algebra 1 End-of-Course Assessment Using Interactive Whiteboard Technologies

SPONSOR: None

I am pleased to advise you that the University of Florida Institutional Review Board has recommended approval of this protocol. Based on its review, the UFIRB determined that this research presents no more than minimal risk to participants. Your protocol was approved as an expedited study under category 7: *Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.*

Given your protocol, it is essential that you obtain signed documentation of informed consent from each participant over 18 years of age and from the parent or legal guardian of each participant under 18 years of age. Enclosed is the dated, IRB-approved informed consent to be used when recruiting participants for the research.

> Given your protocol, it is essential that you obtain signed documentation of informed consent from each participant over 18 years of age and from the parent or legal guardian of each participant under 18 years of age.

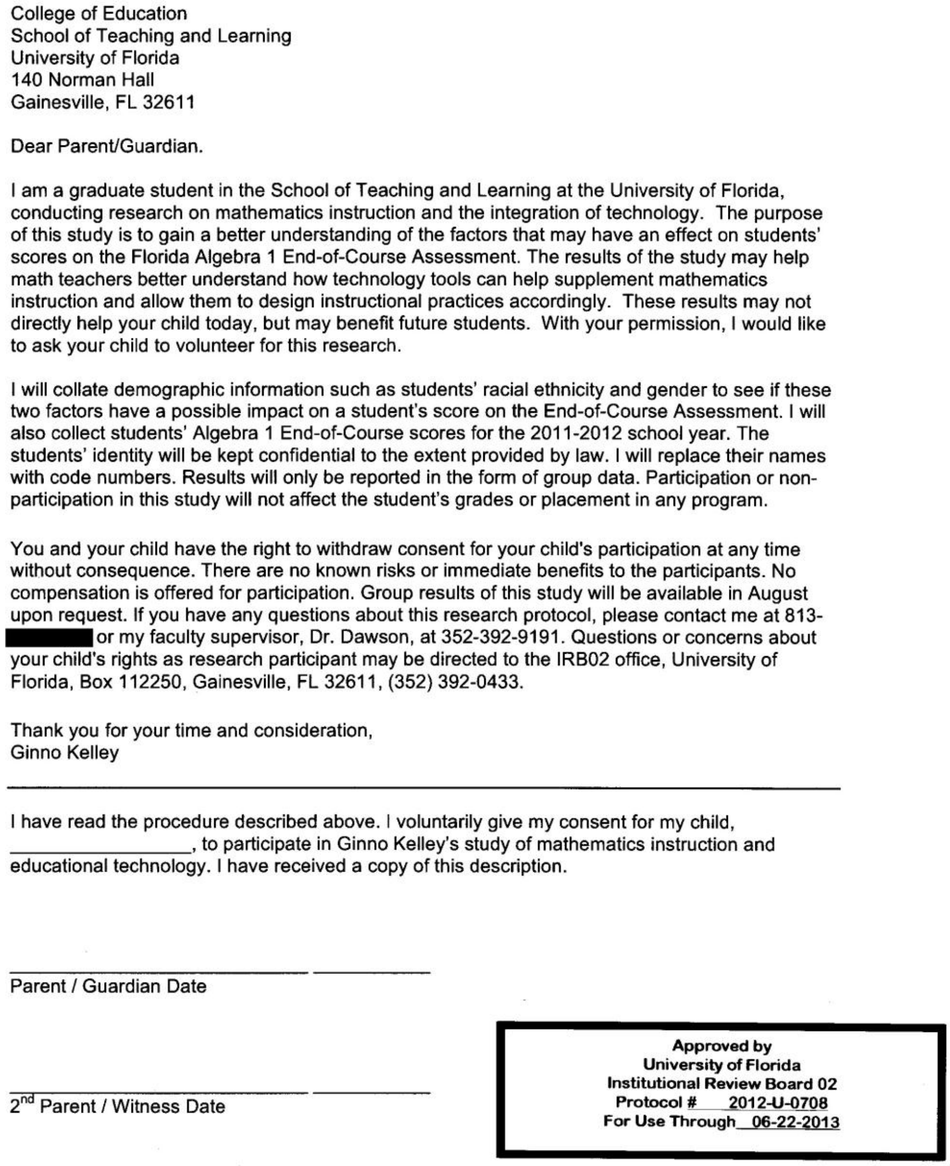
If you wish to make any changes to this protocol, *including the need to increase the number of participants authorized*, you must disclose your plans before you implement them so that the Board can assess their impact on your protocol. In addition, you must report to the Board any unexpected complications that affect your participants.

The approval of this protocol is valid through **June 22, 2013**. If you have not completed this study by this date, please telephone our office (392-0433), and we will discuss the renewal process with you. It is important that you keep your Department Chair informed about the status of this research protocol.

ISF:dl

An Equal Opportunity Institution

APPENDIX D
CONSENT FORMS



College of Education
School of Teaching and Learning
University of Florida
140 Norman Hall
Gainesville, FL 32611

Dear Parent/Guardian.

I am a graduate student in the School of Teaching and Learning at the University of Florida, conducting research on mathematics instruction and the integration of technology. The purpose of this study is to gain a better understanding of the factors that may have an effect on students' scores on the Florida Algebra 1 End-of-Course Assessment. The results of the study may help math teachers better understand how technology tools can help supplement mathematics instruction and allow them to design instructional practices accordingly. These results may not directly help your child today, but may benefit future students. With your permission, I would like to ask your child to volunteer for this research.

I will collate demographic information such as students' racial ethnicity and gender to see if these two factors have a possible impact on a student's score on the End-of-Course Assessment. I will also collect students' Algebra 1 End-of-Course scores for the 2011-2012 school year. The students' identity will be kept confidential to the extent provided by law. I will replace their names with code numbers. Results will only be reported in the form of group data. Participation or non-participation in this study will not affect the student's grades or placement in any program.

You and your child have the right to withdraw consent for your child's participation at any time without consequence. There are no known risks or immediate benefits to the participants. No compensation is offered for participation. Group results of this study will be available in August upon request. If you have any questions about this research protocol, please contact me at 813-[redacted] or my faculty supervisor, Dr. Dawson, at 352-392-9191. Questions or concerns about your child's rights as research participant may be directed to the IRB02 office, University of Florida, Box 112250, Gainesville, FL 32611, (352) 392-0433.

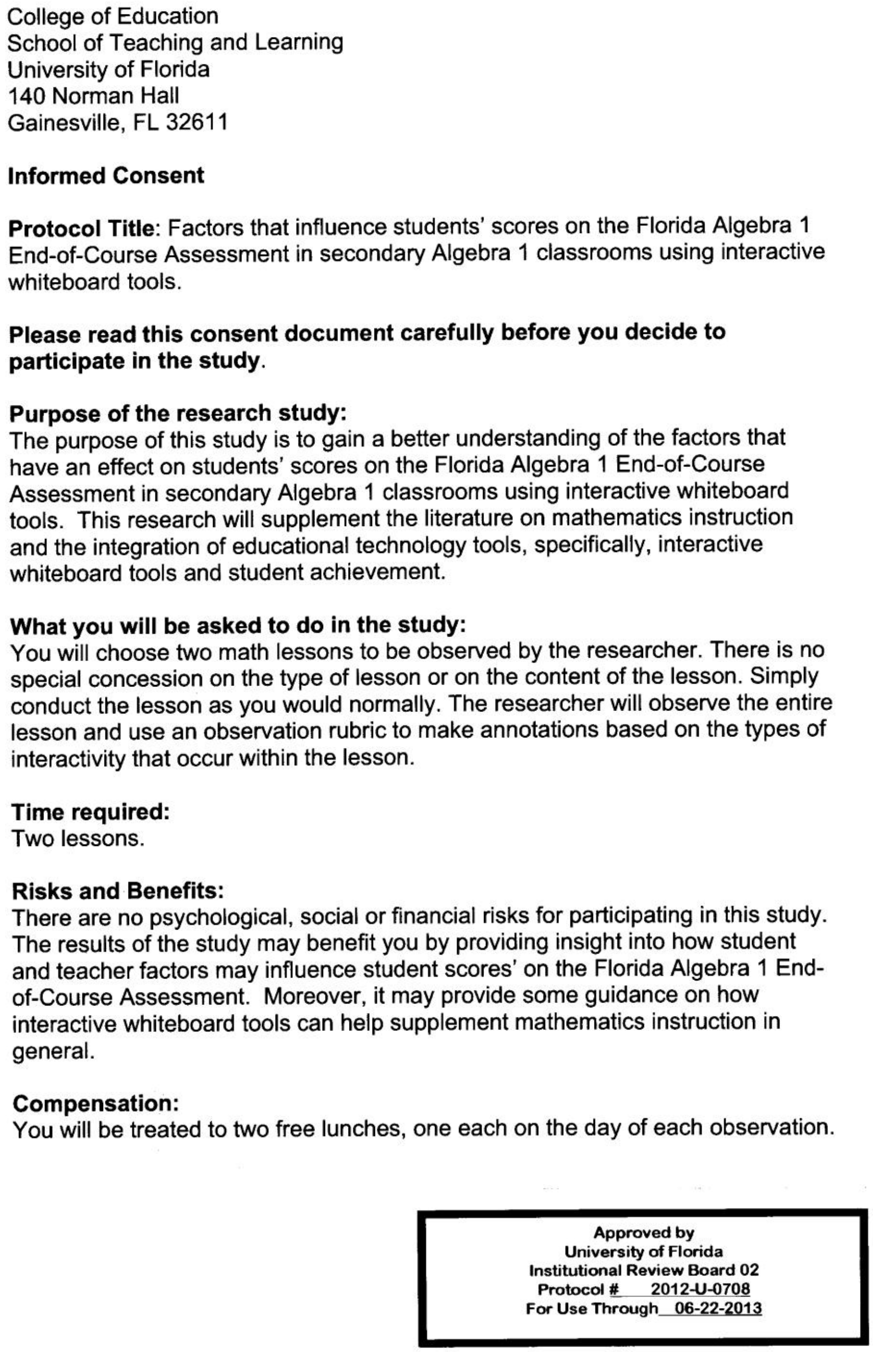
Thank you for your time and consideration,
Ginno Kelley

I have read the procedure described above. I voluntarily give my consent for my child, _________________, to participate in Ginno Kelley's study of mathematics instruction and educational technology. I have received a copy of this description.

____________________________ ___________
Parent / Guardian Date

____________________________ ___________
2nd Parent / Witness Date

Approved by
University of Florida
Institutional Review Board 02
Protocol # 2012-U-0708
For Use Through 06-22-2013



College of Education
School of Teaching and Learning
University of Florida
140 Norman Hall
Gainesville, FL 32611

Informed Consent

Protocol Title: Factors that influence students' scores on the Florida Algebra 1 End-of-Course Assessment in secondary Algebra 1 classrooms using interactive whiteboard tools.

Please read this consent document carefully before you decide to participate in the study.

Purpose of the research study:
The purpose of this study is to gain a better understanding of the factors that have an effect on students' scores on the Florida Algebra 1 End-of-Course Assessment in secondary Algebra 1 classrooms using interactive whiteboard tools. This research will supplement the literature on mathematics instruction and the integration of educational technology tools, specifically, interactive whiteboard tools and student achievement.

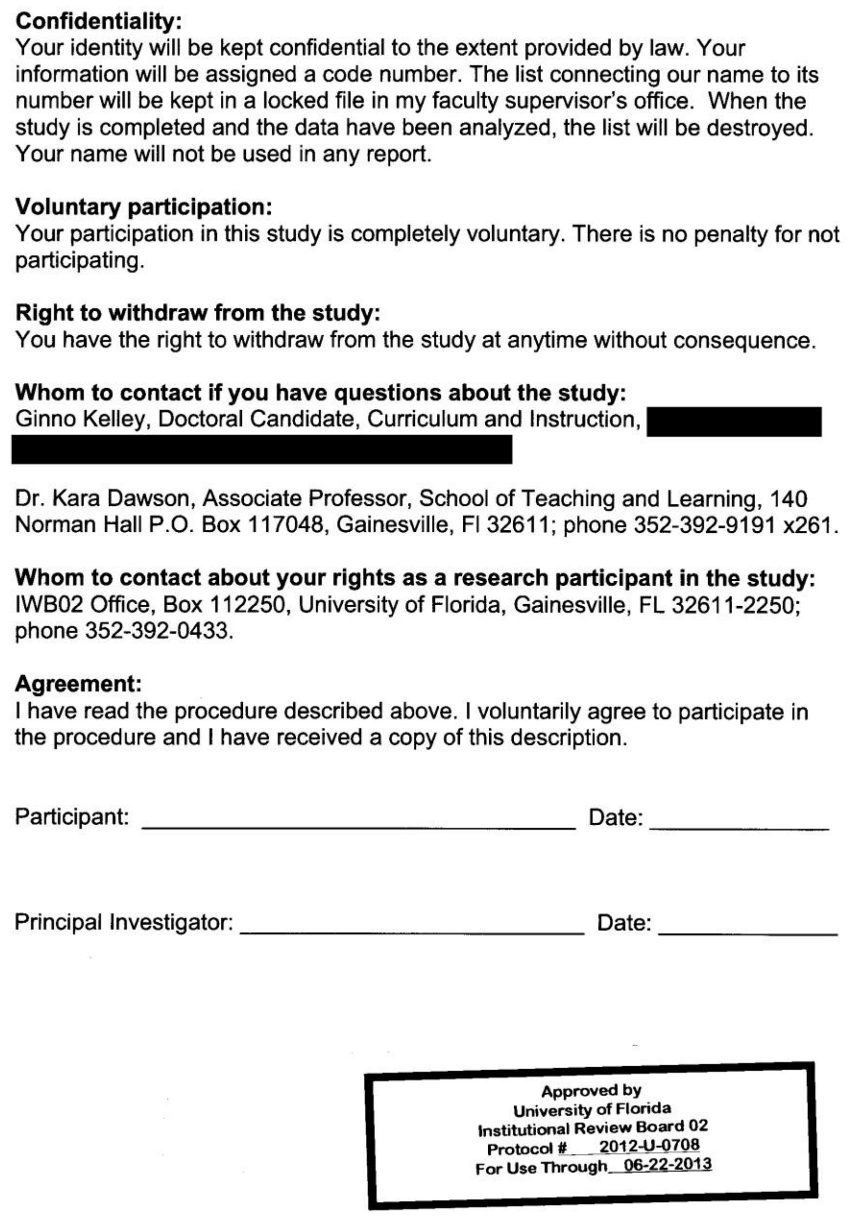
What you will be asked to do in the study:
You will choose two math lessons to be observed by the researcher. There is no special concession on the type of lesson or on the content of the lesson. Simply conduct the lesson as you would normally. The researcher will observe the entire lesson and use an observation rubric to make annotations based on the types of interactivity that occur within the lesson.

Time required:
Two lessons.

Risks and Benefits:
There are no psychological, social or financial risks for participating in this study. The results of the study may benefit you by providing insight into how student and teacher factors may influence student scores' on the Florida Algebra 1 End-of-Course Assessment. Moreover, it may provide some guidance on how interactive whiteboard tools can help supplement mathematics instruction in general.

Compensation:
You will be treated to two free lunches, one each on the day of each observation.

Approved by
University of Florida
Institutional Review Board 02
Protocol # 2012-U-0708
For Use Through 06-22-2013



Confidentiality:
Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting our name to its number will be kept in a locked file in my faculty supervisor's office. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

Voluntary participation:
Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study:
You have the right to withdraw from the study at anytime without consequence.

Whom to contact if you have questions about the study:
Ginno Kelley, Doctoral Candidate, Curriculum and Instruction, [redacted]

Dr. Kara Dawson, Associate Professor, School of Teaching and Learning, 140 Norman Hall P.O. Box 117048, Gainesville, Fl 32611; phone 352-392-9191 x261.

Whom to contact about your rights as a research participant in the study:
IWB02 Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; phone 352-392-0433.

Agreement:
I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: ______________________________ Date: ____________

Principal Investigator: ________________________ Date: ____________

Approved by
University of Florida
Institutional Review Board 02
Protocol # 2012-U-0708
For Use Through 06-22-2013

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BIOGRAPHICAL SKETCH

Ginno Kelley is an Education Strategist at Promethean, a global leader and innovator in interactive learning technology. Prior to his career at Promethean, Ginno Kelley was most recently Assistant Director for the Florida Center for Instructional Technology's Florida Digital Educator Program. The program served teachers from the state of Florida and provided professional development for the creation of technology-rich curricula and the integration of 21st century tools. Mr. Kelley also served as a high school teacher for mathematics and technology for many years. During his teaching career Mr. Kelley has developed innovative projects for helping elementary and high school students in mathematics. He has also worked with struggling students developing cutting-edge multimedia environments that promote student voice and achievement. He regularly presents at national and international conferences on the effects of interactive environments and student learning. Mr. Kelley has international teaching experience and has visited with educational technology leaders from across Europe, the Middle East and the Caribbean to promote the integration and use of interactive technologies. His research interests include technology integration, mathematics education, interactive technologies, special education and critical theory.