EFFECT OF COMPUTER-AIDED INSTRUCTION ON ATTITUDE AND ACHIEVEMENT OF FIFTH GRADE MATH STUDENTS

by

Traci L. Shoemaker

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

July 16, 2013

EFFECT OF COMPUTER-AIDED INSTRUCTION ON ATTITUDE AND ACHIEVEMENT OF FIFTH GRADE MATH STUDENTS

by

Traci L. Shoemaker

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University, Lynchburg, VA

July, 2013

APPROVED BY:

GARY WOODS, EdD, Committee Chair

KRISTEN ASCENCAO, EdD, Committee Member

BETSY BAKER, EdD, Committee Member

Scott B. Watson, PhD, Associate Dean, Advanced Programs

EFFECT OF COMPUTER-AIDED INSTRUCTION ON ATTITUDE AND ACHIEVEMENT OF FIFTH GRADE MATH STUDENTS

ABSTRACT

The purpose of this quasi-experimental non-equivalent control group study was to test theories of constructivism and motivation, along with research-based teaching practices of differentiating instruction and instructing within a child's Zone of Proximal Development, in measuring the effect of computer-aided instruction on fifth grade students' attitude and achievement in math. Students in Pennsylvania completed an attitude survey at the beginning, middle, and end of the study (Pierce, Stacey & Barkatsas, 2007). Achievement was measured by the 4Sight Math assessment (Pennsylvania State Education Association, 2007) which was given at the beginning of the study, after the first seven weeks of instruction, and then at the end of the study. Five fifth grade teachers were randomly assigned as treatment or control, indicating which instructional strategy they would implement. Treatment groups received traditional direct instruction and guided practice, and then computer-aided instruction as a supplemental math practice session. Control groups participated in traditional instruction and guided practice, which incorporated Interactive Whiteboards, with only traditional methods used for supplemental practice. Data from the attitude survey were used to indicate changes that students showed after using the computer for practice as compared to using traditional methods of practice. Data from the 4Sight Math assessments were used to determine any changes in achievement after each method was implemented. Results determined that computer-aided instruction did not have a significant effect on student achievement, but did positively impact the attitude of low-achievers.

Acknowledgements

The road to this dissertation has been a long and adventurous journey. It is the culmination of a lifelong academic dream and it never would have come true without the love and support of those around me. My family's love and support has been unwavering throughout this process and I appreciate all the sacrifices they have made to help me do this. My husband, especially, has been an awesome "executive assistant," helping me with the details that I frequently overlook, and continually encouraging me when I was ready to give it up.

I have also had unending support from my friends whose willingness to listen and encourage me has carried me through. Their faith, their prayers and their favorite scriptures have given me the strength and courage to continue what I have started because as they repeatedly reminded me, "For I know the plans I have for you, declares the Lord, plans to prosper you and not to harm you, to give you a hope and a future …" (Jer. 29:11, NKJV).

Naturally, my committee and research consultant, Dr. Watson, have been invaluable in offering advice and encouragement throughout this final stage of the journey as well. I have truly appreciated their willingness to offer feedback and advice in a gentle and uplifting way. Thank you so much for your time and sharing your expertise!

Above all, however, I owe all that I am and all that I have accomplished to my Savior, Jesus Christ. It is He who strengthens me, gives me wisdom, and provides me with the courage to do more than I ever imagined possible.

Table of Contents

List of Tables

List of Figures

CHAPTER ONE: INTRODUCTION

With the rapid advances in technology and its impact on society, education must respond to help students meet the changing needs of the 21st century job market (Gorder, 2007; Maninger & Holden, 2009; Ritzhaupt & Hohlfeld, Barron, & Kemker, 2008; Uibu & Kikas, 2008). Education Secretary Duncan reported that due to the global economy schools need to take new approaches to teaching and learning (U.S. Department of Education, 2013). One possible solution, to best meet the needs of all learners, is to incorporate technology in instruction (Chambers et al., 2011; Christmann & Badgett, 2003; Deffenbaugh, 2010; Neill & Matthews, 2009; Nordness & Haverkost, 2011). There are many technological tools available that can empower teachers and help today's students learn essential content and skills efficiently and effectively (Blue & Tirotta, 2006; Cavanaugh, Dawson, & Ritzhaupt, 2011; Dreon, Kerper & Landis, 2011; Dunleavy, Dexter & Heinecke, 2007; Frye & Dornisch, 2008; Manny-Ikan, Tikochinski, Zorman & Dagan, 2011). These tools can also be effective in helping to engage students in the learning process and motivate them to achieve to their highest ability (D'Angelo & Wooley, 2007; Dresel & Haugwitz, 2008; Fenfeng, 2008; Furner & Marinas, 2007; Gillispie, Martin & Parker, 2010; Gorra, et al., 2010; Hansen & Williams, 2003; House & Telese, 2011; Qing & Xin, 2010). In fact, a United States government report lists several positive outcomes for using technology in the classroom, including the following: broadening access to academic content, increasing active student learning, differentiating instruction, personalizing instruction to meet student interest, automating routine teacher tasks, and improving student learning (U.S. Department of Education, 2012). In addition, President Obama exhorts schools to focus on Science, Technology, Engineering, and

Mathematics (STEM) education, using technology as a central element to teaching and learning (U.S. Department of Education, 2013). This study meant to examine the effect of a software program called Study Island on the achievement and attitude of fifth grade students in mathematics.

This chapter provides a brief background regarding student achievement and attitude in math, as well as a social, historical, and theoretical framework for the study. It also outlines the problem being examined, the purpose of the study, and the significance of the research. In addition, the research questions and hypotheses are included in this section. The chapter closes with the identification of variables and definitions of terms used.

Background

Technological advances affect every part of life. The Internet, cell phones, personal digital assistants, digital notebooks, and personal computers are continually changing the way people communicate and learn. In addition, jobs in the 21st century demand a variety of technological skills and abilities such as information processing, problem solving and critical thinking (Murray, 2003; Nagel, 2012). In fact, information analysis and the use of technology are listed as two of five essential competencies required for employment according to the Secretary's Commission on Achieving Necessary Skills (SCANS) (Murray, 2003). In the book, *Disruptive Innovation*, Christensen, Johnson, and Horn (2008) state that education needs to transform and take advantage of the technology innovations available. They claim that this will help teachers to individualize instruction, and make learning more student-centered. Education, consequently, is changing to better meet the needs of today's students.

The Partnership for 21st Century Skills recently released its new Math Skills Map which provides guidelines for integration of technology into core subjects such as math, science and language arts (Nagel, 2012). Its purpose is to streamline the curriculum while making learning more engaging and relevant. It is also meant to help students develop a deeper understanding of the content (Partnership for 21st Century Skills, n.d.). Change, such as this, is needed to help prepare students to compete in a global society in which critical thinking, problem solving and collaboration are required (Nagel, 2012).

Concern about student achievement spiked dramatically in 1983 with the publication of “A Nation at Risk.” In this report, United States students were shown to have serious deficits in their education. Approximately 13% of 17 year-olds were considered illiterate, Scholastic Aptitude Test (SAT) scores were dropping, and many students attending college required remedial courses in order to be successful (U.S. Department of Education, 2008). This spurred the government to further research the problem and make recommendations to improve our educational system. In 2006 Pres. Bush gathered a group of experts to create the National Mathematics Advisory Panel. After two years of intensive research and debate, this panel published a comprehensive report outlining what they called the “Foundations for Success: The Final Report of the National Mathematics Advisory Panel” (National Mathematics Advisory Panel, 2008). The report states that instructional technology has shown overall positive results in students’ math achievement and recommends continued quality research in studying the effects of computer-aided instruction. In response to this report and others, the United States has made many changes in educational policy. In addition, individual states have implemented standards-based learning which is now measured with standardized tests and reported to the public (U.S. Department of Education, 2008).

Despite these changes, students in the United States are still behind their international counterparts in math achievement (Plitt, 2008). American students are currently ranked 10th internationally falling behind such countries as Japan and China (Martin, Mullia, & Foy, 2008). To add to the challenge, *No Child Left Behind* legislation, enacted in 2001, is demanding 100% of students demonstrate proficiency on standardized state tests in reading, writing, and math by 2014. Currently students in Pennsylvania have not reached this goal. According to the 2012 Pennsylvania System of State Assessment (PSSA) results, approximately 27% of fifth grade students scored in the basic or below basic range in math (Pennsylvania Department of Education, 2013). In addition, over 50% of students with an Individualized Education Plan (IEP) failed to reach proficiency in math (Pennsylvania Department of Education, 2013.). Obviously, this problem needs to be addressed.

Many schools have attempted to increase the achievement level of students by implementing research-based practices. Some instructional approaches that have been proven effective are differentiating instruction, instructing within a student's Zone of Proximal Development, and motivating students to want to learn (Huebner, 2010; Vygotsky & Lozulin, 2011; Twenge, 2009). Using technology effectively can incorporate all of these theories.

Much research has shown that instructing with Interactive Whiteboards (IWB) increases motivation and student engagement in elementary, middle, and high school students (Blue & Tirotta, 2011; Manny-Ikan, et al., 2011; Merrett & Edwards, 2005;

Richardson, 2002; Shenton & Pagett, 2007). In addition, this technology tool has made it possible to interact with content, view simulations, and participate in real world problem-solving activities (Blue & Tirotta, 2011). Another research-based trend in technology in education has been to provide a laptop for every student. In fact, in the year 2000, there were approximately 1,000 schools in the United States implementing a 1:1 model of laptops to students (Dunleavy, et al., 2007). The premise is that access to computers will increase motivation and therefore achievement for all students. Maninger and Holden (2009) discovered high levels of integration of technology use in Texas schools with laptops for every middle school student. They reported several positive outcomes of laptop use. First, laptops engaged the students, allowed teachers to easily accommodate for individual learning, and gave students greater access to a variety of content material. Teachers also reported higher student involvement and deeper understanding of the content when using the technology.

This use of technology addresses the needs of today's learners as well. Born after 1982, the current generation of students, called the Millennials, is considered to be digital natives, having grown up with a vast array of technology influencing their everyday lives (Ransdell, Kent, Gaillard-Kenney, & Long, 2011). These students reportedly need interactive learning and they respond positively to the use of multi-media (Ransdell, et al., 2011; Twenge, 2009). Technology, therefore, helps to provide the motivation they need to learn.

In addition to meeting the motivational needs of these tech-savvy individuals, teachers also work to meet the diverse instructional needs of each student in the classroom. In most elementary classrooms, students range in ability from gifted, high achievers to students with moderate to severe learning disabilities. Designing lessons that meet this wide range of instructional levels is quite challenging, but again many computer programs can easily be adapted to increase or decrease the level of difficulty of practice. Most programs can also provide additional instruction or enrichment as needed. The question that remains, therefore, is whether this approach is more effective than other traditional instructional methods for best meeting the motivational needs of all learners while helping students to attain the highest level of achievement possible.

To best prepare today's learners for the global job market in the 21st century, schools need to improve their instructional practices. The pressure to ensure that every student is proficient in reading, writing, and math adds to the imperativeness of this endeavor. One possible answer is to incorporate technology which has been shown to be engaging and effective in increasing the depth of student learning. The challenge, however, is finding the most effective means of using technology to maximize student performance. For these reasons, this study researched the effectiveness of implementing computer-aided instruction using a standards-based software program in increasing student motivation and achievement in fifth grade students in mathematics.

Problem Statement

To help improve the quality of education and to better prepare students for our technology rich society, schools have invested large amounts of money in computers and other equipment. Many schools have invested in equipment such as laptops for every student and IWBs for classrooms (Persch, 2008; Shenton & Pagett, 2007). IWBs allow for student interaction, and provide multi-media resources that are motivating and engaging for students. In addition, student laptops have been used with an effective constructivist learning approach, as well as for simple drill and practice of essential skills.

Simply having access to these tools, however, does not ensure that they are used effectively. A study conducted by Larkin and Finger (2011) found that even when provided with a laptop for every student, teachers used them on a very limited basis. The reason given for this is threefold: some teachers lack the technological knowledge necessary to use the equipment, the teachers' schedules do not always allow adequate time to plan for use of the equipment, and the curriculum is so crowded that teachers do not have the instructional time to implement the technology. It is imperative, therefore, for schools to determine how technology can be used most effectively and efficiently before making these large investments.

This study examined the effectiveness of implementing software aligned with Pennsylvania's state standards and the Common Core standards as supplemental mathematics instruction when compared with more traditional instruction, which included the use of IWBs, in fifth grade classrooms. The software program can be adapted to set goals for student learning within their individual Zone of Proximal Development, providing practice that is challenging but not frustrating for students at both ends of the learning spectrum. The program also provides a visually stimulating environment, and is self-paced and interactive which helps teachers to differentiate instruction to meet the different learning styles of the students. For this reason, it was proposed that using it for supplemental mathematics instruction would be motivating for students of all ability levels. Traditional instruction, which incorporates the use of IWBs, can also provide many of these same learning advantages for whole class instruction.

The essential question, then, was how effective is the use of a standards-based software program in motivating students to learn while also meeting the educational needs of all students, especially in mathematics?

Purpose of Study

The purpose of this quasi-experimental non-equivalent control group study was to examine the impact of supplemental instruction using a standards-based software program on the fifth grade students' academic performance and attitude regarding mathematics when compared to more traditional instructional methods that utilize IWBs. The study took place in south-central Pennsylvania in a small, rural school district which has already invested a considerable amount of money in technology equipment, software, and teacher training. Each classroom included in the study has an IWB and access to individual laptops for each student. The independent variable of interest in this study is generally defined as standards-based mathematics software with the control variable generally defined as traditional instruction which includes the use of IWBs. The majority of research literature indicates that the use of technology can positively impact the learning of lower-achieving students, but little research is available regarding the advancement of higher-achieving students. They, too, need to be challenged to excel to their highest potential. In addition, there is little empirical data regarding the effect of technology on the motivation of higher achieving elementary students, which can directly impact academic achievement. This study aimed to add to the literature regarding the effectiveness of technology on the achievement and motivation of students of all ability levels.

Significance of the Study

Schools rely on federal and state funding to support many programs offered to students. Budget cuts on all levels have forced schools to closely examine how they spend these funds. In addition, pressure is mounting to have all students reach proficiency by 2014 on state assessments in mathematics. This study offers some insight into the effectiveness of a standards-aligned software program on the motivation and achievement of students of all ability levels so that districts can make better informed financial and instructional decisions. It also adds to the literature since there is little empirical research on the effect of technology on student motivation in regard to elementary high-achieving students.

Research Questions

The six research questions addressed in this study follow.

1. How do the scores of the 4Sight Math assessment (form 4) differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

2. How do the scores of the 4Sight Math assessment (form 4) differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

3. How do the scores of the 4Sight Math assessment (form 4) differ between high-achieving fifth grade students receiving computer-aided instruction using a

standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

4. How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

5. How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between low achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

6. How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between high achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

Hypotheses

H_1: There will be no statistically significant difference between 4Sight Math assessment scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

H_2: There will be no statistically significant difference between 4Sight Math assessment scores of low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

H_3: There will be no statistically significant difference between 4Sight Math assessment scores of high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

H_4: There will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

H_5: There will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade low- achieving students receiving computer-aided instruction using a standards-based software program and fifth grade low-achieving students receiving traditional instruction utilizing an Interactive Whiteboard.

H_6: There will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade high-achieving students receiving computer-aided instruction using a standards-based software program and fifth grade high-achieving students receiving traditional instruction utilizing an Interactive Whiteboard.

Definition of Terms

The following terms, listed alphabetically, are defined for clarity of their use in this study.

- **Advanced -** The level of achievement of a student who scores 1483 and higher on the Pennsylvania System of School Assessment for fifth grade math (Data Recognition Corporation, 2010). According to this PSSA Technical Report (Data Recognition Corporation, 2010), "The advanced level reflects superior academic performance. Advanced work indicates an in-depth understanding and exemplary display of the skills included in the Pennsylvania Academic Content Standards" (p. 230).

- **Basic -** The level of achievement of a student if his scores fall into the range of 1158-1311 for fifth grade math (Data Recognition Corporation, 2010). The PSSA Technical Report (Data Recognition Corporation, 2010) labels a basic student as indicating, "… a partial understanding and limited display of the skills included in the Pennsylvania Academic Content Standards. This work is approaching satisfactory performance, but has not yet reached it" (p. 230).
- **Below Basic** - The level of achievement of a student who scores 700-1157 on the fifth grade PSSA math assessment (Data Recognition Corporation, 2010). A student who falls into this category is identified as one whose work, "… indicates little understanding and minimal display of skills included in the Pennsylvania Academic Content Standards" (Data Recognition Corporation, 2010, p.230).
- **Computer-aided instruction -** A teaching method which incorporates the use of computer software programs (Uibu & Kikas, 2008).
- **Differentiated Instruction -** Instruction that teachers intentionally plan to be different for each child and is designed to best meet each individual's learning needs (Huebner, 2010).

- **Digital Native -** A person born after 1980 (Deffenbaugh, 2010). Each of the participants in the study is considered a digital native.
- **4Sight Math Assessment -** A test used to measure student achievement in mathematics. It is a formative assessment for students in third through eighth grade meant to give students practice test questions in the assessed content area to familiarize them with the types of questions asked, and the format of the test. It is also designed to provide feedback to teachers regarding student performance in each learning category, thus allowing them to adjust instruction accordingly. This assessment has also been correlated with actual PSSA results, so it is also used as a predictor of a student's success on this state assessment (Pennsylvania State Education Association, 2007).
- **Generation Me -** A person born after 1970, and particularly those born after 1980 (Twenge, 2009). Each of the participants in the study could also be called part of "Generation Me."
- **High-achieving student or advanced learner -** A student who scores in the advanced range on the fourth grade PSSA math assessment or who has scored advanced on the 4Sight math assessment (Form 2) given as a baseline in fifth grade with no score in the basic or below basic range (Manning, Standford, & Reeves, 2010).
- **Individualized Education Plan (IEP) -** A document – developed by a team of certain individuals as defined by law – which outlines specific educational goals, strategies, etc. designed to best meet the instructional

needs of a student who qualifies for special education services (U.S. Department of Education, Office of Special Education and Rehabilitation Services, 2000).

- **Interactive Whiteboard (IWB) -** An electronic display board connected to a projector and computer, which enables images to be projected from the computer onto the board. Users control the computer at the board through a pen, finger or other device ("Interactive Whiteboard," Wikipedia, n.d.).
- **Low-achieving students -** A student who scores in the basic or below basic range on the fourth grade PSSA math assessment and who scores in the basic or below basic range on the 4Sight math assessment (Form 2) used as a baseline in fifth grade.
- **Mathematics and Technology Attitude Scale (MTAS) -** An instrument used to measure student attitude toward mathematics and the use of technology in mathematics (Pierce, et al., 2007).
- **Millennials -** A person born after 1980 (Ransdell, et al., 2011). Each of the participants in the study is considered part of this generation.
- **National Council of Mathematics (NCTM) -** An organization of teachers of mathematics of all levels whose mission is to promote quality instruction in mathematics for all students, based on research and adherence to the highest professional standards (National Council of Teachers of Mathematics, 2011).

- **Pennsylvania System of School Assessment -** A standards-based, criterion-referenced test given to third through eighth grade students to determine academic achievement and to report schools' adequate yearly progress to the public (Data Recognition Corporation, 2010).
- **Proficient -** The level of achievement indicated by a student who scores 1312-1482 on the Pennsylvania System of School Assessment for fifth grade math (Data Recognition Corporation, 2010). The PSSA Technical Report (Data Recognition Corporation, 2010) defines a proficient student as one who, "… reflects satisfactory academic performance. Proficient work indicates a solid understanding and adequate display of the skills included in the Pennsylvania Academic Content Standards" (p.230).
- **Standards-based learning -** An educational approach in which concrete objectives are implemented so that each student is held to a specific standard of performance or achievement (Pennsylvania Department of Education Standards Aligned System, n.d.).
- **Standards-based software -** Computer programs that are designed to help students meet specific learning objectives. In this study the software program is aligned with the Pennsylvania math standards as well as Common Core standards and aims to help students master each state learning goal in math (Hayden, n.d.).
- **Supplemental math instruction -** Instruction beyond the usual 60 minutes per day that students are in math class. The supplemental math

instruction will take place three times out of a six day cycle for at least 20 minutes per session.

- **Zone of Proximal Development -** The optimal learning situation in which one can learn with support, as conceptualized by Lev Vygotsky (Powell & Kalina, 2009).

Research Plan

This study followed a quasi-experimental non-equivalent control group design. To prevent disruption to the educational setting, participants were from intact classrooms and were not randomly assigned to treatment or control, although classrooms as a whole were randomly assigned to treatment or control. Participants took a pre-test, mid-term test, and a post-test consisting of different forms of the 4Sight math assessment, a formative assessment designed to simulate the types of questions and standards covered in the Pennsylvania state assessment. Students were also given an attitudinal survey at the beginning, middle, and end of the study to measure any differences that may be attributed to the use of the various technologies. This survey, while geared toward middle school students, is developmentally appropriate for fifth grade students and offered insight into student confidence levels in math, their attitudes towards math and technology, and their level of engagement in math lessons (Pierce, et al., 2007).

Each group received 60 minutes of math instruction daily, using traditional methods which included the use of an IWB in each classroom. In addition, each group received 20 minutes of supplemental math instruction three days out of a six day cycle. During this supplemental instruction time, the control group continued to receive traditional instructional methods incorporating an IWB while the treatment group received computer-aided instruction using a standards-based software program called Study Island. The lessons and practice provided in this program are aligned with the Pennsylvania state standards as well as the Common Core state standards. Each group continued with this type of instruction for seven weeks and then took the mid-term assessment. At this time teachers switched instructional methods for the supplemental math instruction for the next seven weeks. The reason for this switch was to control any pre-existing differences between groups and to ascertain the achievement and attitudinal differences which may be attributed to the treatment. At the end of this seven-week period (14 weeks total) the students were given a final 4Sight math assessment and the attitudinal survey. Results were statistically analyzed to determine if any significant differences existed in attitude or achievement after treatment. Results were also analyzed to see if any significant differences occurred after treatment in the subgroups of high-achieving students and low-achieving students when looking at attitude and achievement.

CHAPTER TWO: REVIEW OF LITERATURE

A child's experiences in elementary school provide a foundation for all of his future education. This initial learning experience can impact the child's educational career, so providing for individual differences and helping students to enjoy learning in their early years is crucial (Parkay, Hass, & Anctil, 2010). This is especially true in mathematics.

With the rapid advances in our technology- based society, math skills are more important than ever. Machines can perform complex calculations almost instantaneously; however, the people using them need to have a solid background in number sense and problem solving (Little, 2009). Considering the advances in technology and the additional teaching tools available, one would expect that our nation's math achievement levels would be stronger than ever. In some respects, this is true. According to the National Council of Educational Statistics (NCES) report, 98% of fourth grade students scored proficient or advanced in simple facts and 89% scored proficient or advanced in beginning math skills (National Center for Educational Statistics, 2011). Only 44.5% of fourth grade students, however, scored in the proficient or advanced categories in numerical operations and beginning problem solving. *The Trends in Mathematics and Science* (Martin, et al., 2008) also convey some positive and negative information concerning fourth graders' achievement. On the positive side, fourth graders in the United States scored slightly higher on an international mathematics assessment than the international average, with a score of 529 compared to the international average of 500. The United States is still ranked 10th overall in mathematics achievement, however, falling far behind countries such as China and Japan. In addition, only 45% of fourth grade students scored at the proficient or advanced level on the international math assessment.

Much research has been done on the effectiveness of various types of technology on student achievement in math. Fengfeng (2008), for example, found that using computer games in math increases achievement in elementary students, especially when used with a cooperative learning approach. In addition, virtual manipulatives were shown to help fourth graders to increase their conceptual understanding of fractions because of the immediate feedback the program offered (Reimer & Moyer, 2005). Online content, virtual lecture halls, and the use of Interactive Whiteboards (IWB) are other tools that have been shown to increase student's math achievement (Cramer, Collins, Snider & Fawcett, 2007; Hansen & Williams, 2003; Shenton & Pagett, 2007).

One major factor that impacts a student's achievement level is his motivation to learn. Yucel and Koc (2011) found a strong correlation between sixth through eighth grade students' attitude and achievement in math. Their study showed that a one unit increase in positive attitude score was associated with a 0.7 increase in math grades, scaled from one to five. These results are supported by a meta-analysis of student attitudes in reading as related to reading achievement. Petscher (2010) found a moderately strong relationship between attitudes and achievement in reading with elementary students. He concludes, therefore, that it is important to determine how to strengthen these positive attitudes in order to also strengthen achievement.

Many studies have linked technology use and student attitude at the college level. Hansen and Williams (2003) found that students are more interested and motivated to learn when the instructor uses online resources in class. College students also perceive that they are learning more when the instructor incorporates technology into the lessons (D'Angelo & Wooley, 2007). Studies also show that technology use also impacts the attitude of middle school students. Gillispie, Martin, and Parker (2010) found that using a 3-D video game based program had a positive influence on the attitude and self-efficacy of students in a remedial math course. Elementary students have also been shown to respond positively to the use of technology in math instruction, but this research is limited. This is an area worth examining further. Teachers need research-based strategies and teaching methods which will help elementary students to gain positive attitudes which can affect their future performance in mathematics, and the use of technology seems to have vast potential.

This review of literature begins with the theoretical framework surrounding the implementation of computer-based instruction and basic good teaching practices in elementary mathematics. This is followed by a historic summary of the legislation demanding 100% proficiency in math for all students, regardless of ability or attitude, by the year 2014. Next the current trends of computer use in today's classrooms are examined, as well as the current recommendations for effective mathematics instruction. Finally, research on the effectiveness of computer-aided instruction is reviewed in light of its effect on student attitude and achievement.

Theoretical Framework

Constructivism. This study intends to examine the effectiveness of computer-aided instruction on student attitude and achievement in math. A constructivist teaching framework helps to foster student motivation and achievement and this theory is easily married to the use of technology. The theory of constructivism states that students need to construct their own meaning based on a learning experience (Powell & Kalina, 2009). This mirrors Piaget's theory of learning where students build and modify schema based on their exposure to new information. Piaget also stated that optimal learning takes place when a child experiences "disequilibrium" and has to change his thinking to accommodate the new information (Piaget, 1964). This can only take place if the new knowledge is within the child's level of cognitive development.

Dewey also believed that students should be actively involved in the learning process. Students should be observed and learning should be evaluated on an ongoing basis so that instruction can be changed and adapted to best meet their needs and interests. Building upon this theory, Jerome Bruner stated that lessons should be structured for ease of understanding. Teachers should provide the students with information that causes them to experience "disequilibrium" so that they want to explore and fill in the gaps created by the teacher's instruction (Gutek, 2005).

In addition, Vygotsky found that learning requires a communication process, whether it is with another person or self-talk (Vygotsky & Kozulin, 2011). Social interaction is a critical piece of learning because communicating concepts and ideas helps students develop deeper understanding of the content (Powell & Kalina, 2009). By partnering students to have them share what they have learned or by having them debrief in writing after a lesson, this communication becomes an integral part of the learning process.

The constructivist theory is also supported by current research in the use of scaffolding for student learning. Scaffolding provides support and assistance when a concept is first introduced to give students a solid foundation. As the students become more confident and competent, the support is removed and the students are moved toward independence (Anghileri, 2006). A constructivist approach to teaching helps to motivate students because it requires their active engagement in the learning process, delivers instruction at an appropriately challenging level, provides the support students need to succeed, and allows for social interaction. Both computer-aided instruction and traditional teaching can be implemented to support this type of learning.

Differentiated instruction. A positive attitude is important because it compels a student to learn and to do his best work. One way to foster this positive attitude is to gear instruction to meet the child's individual learning needs. When differentiating instruction, the teacher provides instruction and guidance for every student so that each will learn and grow as much as possible every day (Huebner, 2010). In a typical third grade classroom students vary greatly in ability in math. Some are gifted, acquiring concepts easily and understanding complex operations easily. Others have mild to severe learning disabilities, requiring much review and repetition in order to master the basic elements of mathematics. The majority of students' abilities fall somewhere in between these two extremes. For this reason, teachers must differentiate instruction to support the struggling math student as well as to provide adequate challenge to the high achieving student.

Many options for differentiation are available to the teacher when using computer-aided instruction. If a student has difficulty reading, for example, a text-to-speech option can be used to help that student access the information. Content can also be leveled to match the learner's ability level. Teachers can provide these adaptations in traditional ways as well. The teacher can, for example, assign a partner to the student with the reading disability, or she can assign alternative practice problems for the gifted students.

In addition to varying the content of the lesson and the delivery method, teachers must also try to appeal to the learner's preferred style of learning. Kolb's learning model states that students use and respond to a variety of learning strategies that correspond with how effective the learning activities are and how comfortable the students are when learning (Orhun, 2007). Wang, Wang, Wang, and Huang (2006) found a significant link between instruction that met a students' learning style and the student's achievement. When examining student achievement in math, Alloway, Banner, and Smith (2010) found that students with high working memory could excel despite the mode of instruction the teacher used. Students with low working memory however were strongly affected by the instructional technique. This supports the findings of Orhun (2007) who found that matching instruction with a student's preferred style of learning increases his achievement level. Some students are very social, for example, and thrive when interacting with their peers in class or with virtual characters. Kolb describes these students as "assimilators" (Orhun, 2007). Others need to manipulate objects and interact with the content, which is possible when using the computer mouse or other more traditional materials. Kolb would consider these individuals "convergent" learners. Both computer-aided instruction and traditional approaches appeal to a variety of learning styles.

In addition to considering learning styles, teachers must also consider the whole child when designing instruction. Boys, for example, have different learning needs than girls (Gurian & Stevens, 2004). Researchers have studied brain scans of boys and girls and have found significant differences which led to the development of teaching strategies that best meet the needs of each gender. This gender difference should be addressed in the classroom and can be with either traditional instruction or computer-based learning. Teachers can allow boys to have more space and movement that they require, while adding a competitive edge to some activities which appeals to the male learner. By adding a language component to math lessons, the verbal connection can help girls to understand math symbols and formulas.

A further component that should be considered is a student's multiple intelligences. Gardner (1998) described seven types of intelligences that individuals possess: (a) spatial-visual, (b) kinesthetic-movement, (c) linguistic-verbal, (d) musical, (e) interpersonal-self and others, (f) intrapersonal-self, (g) mathematical-numbers. Technology can stimulate a number of sensory systems, as well as appeal to multiple intelligences. In an article written by Weiss (2000), entitled "Howard Gardner Talks About Technology," Gardner, in fact, states, "…even when someone is just typing on a keyboard, he or she can think in spatial, musical, linguistic, or bodily intelligences" (p. 54). In regard to implementing these intelligences in the classroom, Gardner (2011) encourages teachers to give students a menu of choices based on this list of multiple intelligences to promote student engagement and satisfaction in learning. Again, lessons can be formulated to meet these various needs using either IWB or computers.

Most of the research on differentiating instruction has been focused on the learning disabled students. Teachers are directed to modify the content, how it is taught, and how the student shows mastery (Broderick, Mehta-Parekh, & Reid, 2005). Specifically, recommendations suggest the need to incorporate cognitive strategies, peer-mediated instruction, and concrete-to-abstract teaching (Cole & Washburn-Moses, 2010). The gifted or high-achieving students require differentiation as well (Manning, et al., 2010). These students need to be challenged to think and excel in the same way that the lower students need to be supported and encouraged. Both computer-aided instruction and traditional teaching methods can be designed to provide this differentiation for students at both ends of the ability spectrum.

Vygotsky's Zone of Proximal Development. Both computer-assisted instruction and traditional teaching allow teachers to level and structure the content so that it is within the child's zone of proximal development. In this theory of learning, Vygotsky describes the optimal learning situation as one in which the student is able to understand the material with help (Powell & Kalina, 2009). This assistance could come from a computer program, a peer or a teacher. If the lower achieving students are struggling with problem solving, for example, the teacher can provide a framework for them to use with a partner or on the computer. On the other hand, a higher achieving student could be presented with more complex problems to solve in class or given the opportunity to work through more difficult problems on the computer.

Motivation to learn. Another crucial aspect of educating children is inspiring them to want to learn. Hannula (2006) defines motivation as the potential to affect behavior by controlling circumstances in a way to affect the student's emotions. He states that students need autonomy, a feeling of competence, and a sense of social connectedness. Maslow's theory of motivation states that once a child's basic needs are met, he is ready to strive to reach his fullest potential through learning that which sparks his interest (Hackman & Johnson, 1991). In addition, Carl Rogers created an educational framework which relies heavily on student interest and progress (Szlarski, 2011). Setting learning goals is also very motivating to students (Hannula, 2006). Salanova, Llorens, and Schaufeli (2011) conducted research on teachers and college students to examine the connection between efficacy beliefs, affect and engagement. They found in both groups that efficacy beliefs influence engagement which in turn gives the individual a positive affect. Enthusiasm, in their results, showed the strongest impact on engagement in the activity. Most importantly, however, they found that a "gain spiral" exists so that when efficacy beliefs increase due to engagement, positive affect also increases. The key, therefore, is to determine how to help elementary students gain this confidence that they can learn math and develop a positive attitude toward learning so that their engagement also increases. Both computer-aided instruction and traditional teaching can provide conditions for the child to be highly involved in the learning process and provide immediate feedback regarding his progress. Computer programs are motivating in that they present levels to master and teachers can help motivate students by setting attainable goals for mastery in the traditional classroom. The question that remains, then, is which is more effective with today's learners?

Meeting the needs of today's learners. Is computer-aided instruction the best way to motivate and instruct modern students? Students in classrooms today are quite different and have different learning needs than they did even 20 years ago. In the article, "Generational Changes and Their Impact in the Classroom: Teaching Generation Me," Twenge (2009) identifies several predominant characteristics of modern learners. She used a method she calls "cross-temporal meta-analysis" in which she examined the statistical results from a variety of psychological questionnaires across various periods of time to discover generational differences. The results show that Generation Me students have high expectations for themselves, exude a sense of entitlement, and exhibit more mental health problems than previous generations. Most applicable to instructional practice is her assertion that today's students score higher on standard IQ tests, but have very little stamina for long-term concentration.

Other studies show similar characteristics of this generation of students. Gorra, et al. (2010) stated that these "Digital Natives" view technology as an essential part of their everyday life. These authors surveyed college undergraduate students over a period of four years to identify trends in the technology preferences of these students. Their findings showed that 98% of these students carry some kind of communication device daily and most have devices for listening to music, viewing videos, and accessing the Internet. These students report that they appreciate options in modes of instruction, such as downloading lectures, content or other multi-media sources.

Schools are trying to determine what changes are needed to best meet the needs of this modern learner, and the U.S. Department of Education is encouraging professional development in the use of technology (Frye & Dornisch, 2008). Consequently, more and more teachers are implementing technology in all subject areas. Frye and Dornisch (2008) studied the consequences of increasing the use technology in high school classes. They discovered that students perceive teachers who use technology as part of their instruction as more competent and knowledgeable, especially in the areas of math and science. This again reflects the characteristics of this technologically geared generation because using technology involves more student interaction with the content and more active involvement. Recommendations for reaching this type of learner, therefore, include more interactive learning, shorter instructional periods, and the incorporation of multi-media (McAndrew, 2010; Twenge, 2009). Both traditional classroom teaching and computer-aided instruction can accomplish this goal.

Historical Summary

No Child Left Behind. In response to the TIMSS and other reports regarding the performance of children in the United States, the federal government implemented *No Child Left Behind*. This legislation has set the staggering goal for all school districts to ensure that every student reaches proficiency in reading, math, science, and writing on state assessments by the year 2014. While rising scores are encouraging at the national level, the National Council of Educational Statistics (NCES) summary shows fourth grade students are falling short of the proficiency mark especially in problem solving (National Center for Educational Statistics, 2011). In Pennsylvania 24% of all fifth graders scored Basic or Below Basic on the Pennsylvania System of State Assessment in math in 2011. While educators are headed in the right direction, more change is needed to help all students become more successful, especially in learning concepts at a deeper level.

IDEA 2004. The inclusion of students with disabilities in the general education classroom is another reason that teaching methods need to change. To make this even more imperative, the passage of *IDEA* requires that all students with disabilities be included in the state assessments and show adequate progress as expected of the regular education students. Approximately 5% to 8% of school-age students are identified with learning disabilities in reading and/or math (Cole & Washburn-Moses, 2010). Of these students, only 8% scored at or above the proficient level on national assessments in math

(National Center for Educational Statistics, 2011). In addition to performing poorly on state assessments, students who experience difficulties in math in elementary school continue to fall behind as they progress through high school, frequently ending up two or more grade levels below their non-disabled peers (Little, 2009). Obviously, this issue needs to be addressed.

Current Trends in Classroom Technology Use

Becker (2008) analyzed the differences in computer use by students across the United States in the years 1998 through 2003. He found three interesting trends. First, there was a general increase in the use of computers, especially in math from 1998 to 2003. He also found that elementary students had opportunity to use computers more frequently than high school students and usage at the high school level was largely impacted by the subject area. The largest influencing factor in the growth of computer usage, however, stemmed from educational policy.

In 1996, President Clinton and Vice President Gore implemented the Technology Literacy Challenge which aimed to spur teachers' use of computers in the classroom by providing them with computers, Internet access and software programs (Becker, 2008). Several national policies since then have also provided incentive for schools to improve their technology resources. In addition, individual states began to implement their own technology policies in order to increase students' access to and use of computers (Becker, 2008).

In light of these policies, and public support at the national, state and local level, the use of technology in the classroom has expanded tremendously in the past ten years. Many schools now provide access to laptops or Palm Pilots for every student (Persch, 2008; Villano, 2007). Access alone, however, does not ensure effective use. For example, Larkin & Finger (2011) found that when Net books were made available to each student at either a one-to-one or one-to-two basis, they were used minimally. Reasons for the limited use were mostly attributed to lack of teacher comfort and familiarity with the technology as well as a crowded curriculum.

On the other hand, there are many schools that are embracing a variety of technology as part of the curriculum. To do this effectively, several essential factors have been identified. These include adequate professional development, support, and technology resources (Cavanaugh, et al., 2011). Studies have shown that implementation of technology with these aspects in place can have a positive impact on student attitude and achievement in a variety of subject areas, including math (Ozel, Yetkiner, & Capraro, 2008).

In South Dakota, for example, Gorder (2007) reports that the state has a goal of ensuring that every high school student has access to a laptop or tablet computer. To make this a reality, schools have partnered with Dakota State University, and several area businesses in a project they call Classroom Connections. Twenty school districts were chosen to pilot the program, funded in part by Citibank. Gateway computers were offered to the districts for purchase at discounted prices to make the financial burden manageable for the identified schools. Professional development, a key to the success of the program, was provided by Dakota State University. After the pilot schools completed a one-year implementation, the state decided to expand the program to another 20-30 districts who applied to receive funding. Results from the pilot schools indicated that students were more engaged, teacher interaction with students improved and discipline referrals decreased. This report has some positive implications for the use of technology; however, it does not provide empirical evidence to back its findings.

The trend of increasing the availability of computers is not unique to South Dakota. The Florida Department of Education also provided the financial backing for a one-to-one laptop program in 47 of its K-12 schools. The schools were given access to laptops in a variety of levels of access ranging from one-to-one with access 24 hours a day to one-to-one with access from a shared computer cart. Districts provided their own professional development. Findings included significant increases in student engagement in learning and an increase of project-based learning as well as other constructivist-based teaching practices. Of the 47 schools involved in the program, three classrooms reported lower student achievement, reportedly due to the students' inability to use the technology required for the lessons. All other classes reported a significant gain in student achievement (Cavanaugh, et al., 2011). Florida also reports that its K-12 schools are increasingly searching for funding for technology and are using more Title I funding for this purpose (Ritzhaupt, et al., 2008).

In addition to an increase in access to computers for students, schools are also expanding the types of technology being implemented in instruction. Digital storytelling, for example, is a current trend that is gaining popularity. Tyler Binkley, a "Digital Native" now teaching middle school mathematics, has shown that digital storytelling can be an effective medium for helping students struggling to understand difficult math concepts. His vignettes, now available for viewing on YouTube have been shown to increase student comprehension in math (Dreon, et al., 2011). Virtual experiences have also been shown to have a positive effect on student learning. Harlow and Nilsen (2011) conducted a study in which elementary students connected virtually with science majors at a university to perform observations of insects demonstrating equipment to which the younger students would otherwise not have been exposed. The exposure to advanced equipment and the assistance of experts in the field helped students to learn the content at a deeper level.

Miranda and Russell (2011) have found that there are several factors that affect teachers' use of technology in the elementary classroom. These factors include teacher experience with the technology and their belief that it is effective in meeting the learning objectives. The use of IWBs, laptops and software programs, therefore, should be more easily implemented because they are very familiar to most teachers today and would require little investment for schools in the form of professional development.

While little research is available on the use of laptops and software programs in elementary school math in the United States, studies have shown that laptop use has been beneficial for students in learning to write. Suhr, Hernandez, Grimes and Warshauer (2010), for example, have found that the use of laptops and software programs helped fourth grade students to perform better on writing assignments than their counterparts who were taught through more traditional instructional methods. Findings from this study suggested that positive results did not become evident until the second year of implementation because the first year was spent helping the students get used to interacting with the computer and helping teachers gain the expertise needed for the best ways to implement the program (Suhr, et al., 2010). Further research is needed to determine if this same result can be found when using software programs in elementary math classes and to evaluate the effectiveness of the laptop use compared to whole class instruction using IWBs.

Current Trends in Math Instruction

The National Council of Teachers of Mathematics (NCTM) has made many recommendations to improve math instruction for students with and without disabilities. First they recommend a process approach so that students can develop a deeper understanding of mathematical concepts (Little, 2009). Teacher modeling and thinking aloud during problem solving proved to be additional teaching strategies with academic benefits for students with disabilities (Gersten & Clarke, n.d.). In addition, the NCTM recommends that teachers focus on the use of technology in teaching math. They view technology as an essential tool for helping all students to learn (National Council of Teachers of Mathematics, 2012).

The recommendations for improving math instruction fall into three main categories: (a) direct and systematic instruction, (b) differentiated instruction, and (c) peer collaboration. NCTM defines explicit instruction as the teacher demonstrating how to solve various problem types following a specific plan and students applying this plan to thinking through the solution to the problem (Gersten & Clarke, n.d.). Teacher explanation and modeling of steps in the process are key elements of effective instruction. Guided practice and immediate feedback are also very important. This model is supported by the research of Schmoker (2011) who found that students were more successful and more engaged when teachers followed the following fundamental elements of lesson structure outlined by Madeline Hunter: (a) clearly state lesson objectives, (b) clarify what is to be learned, (c) model the strategy or procedure, using a short lesson, (d) provide guided practice, (e) check for understanding often, (f) clarify and reteach as necessary, (g) provide closure by restating the main points of the lesson.

Differentiated instruction is also an important element in teaching mathematics in a classroom in which learning disabled students are included in the regular education classroom along with gifted and high achieving students. This approach is grounded in the belief that all students can learn and succeed (Broderick, et al., 2005). When using differentiated instruction, the teacher must consider what aspects of a lesson may inhibit some students' learning and participation. Then the teacher must alter the learning activity to accommodate the needs of the students. This may include providing a student who has reading difficulty with time to rehearse a section that is to be read aloud to the class, or it could mean giving the more-able student a higher level text from which to read to better meet his instructional needs. By allowing students to demonstrate understanding in a variety of ways, the learning needs of all students with and without disabilities can be more effectively accommodated (Broderick, et al, 2005).

The final essential element of effective instruction is peer collaboration. The National Math Advisory Panel convened by President Bush in 2003 included peer-mediated instruction as one of its recommendations (Cole & Washburn-Moses, 2010). Wadlington and Wadlington (2008) also stated that for students with math disabilities, communication in math is crucial. Students need to be able to explain their thought processes both orally and in writing. Working with peers makes conversation and explanation a natural addition to the learning process. The schools targeted in this study follow these recommendations in their daily math instruction.

Effectiveness of Instruction Using Interactive Whiteboards

The use of IWBs has become rather widespread, and research has shown it to be an effective mode of instruction. Yudt and Columba (2011) state that by 2011 one in seven classrooms in the United States will have IWBs. This technology tool increases student motivation and engagement since it allows the teacher access to a variety of instructional resources and provides for active student involvement in the learning process (Manny-Ikan, et al., 2011; Shenton & Pagett, 2007; Yudt & Columba, 2011).

Several studies show that since IWBs increase student engagement in learning, students' achievement improves (Kaufman, 2009; Marzano, 2009; Prabhu, 2010). Merrett and Edwards (2005) found an increased level of achievement in math thinking skills in classrooms using IWBs. The use of IWBs reportedly increases student motivation and confidence in the subject area which leads to higher achievement (Merrett & Edwards, 2005; Richardson, 2002; Yudt & Columbo, 2011). In addition to increasing student motivation, which can positively affect achievement, IWBs have been shown to increase the depth of student learning in complex topics such as fractions (Linder, 2012). The use of IWBs helps teachers to build a community of learners, make connections with other content areas, and allows a variety of response modes. The versatility of this technology also helps teachers to meet the favored learning style of students in the classroom (Cuthell, 2006).

The presence of the technology alone, however, will not ensure that students will learn more content and learn it to a deeper level (Digregorio & Sobel-Lojeski, 2010). A study conducted by Campbell (2010) showed no significant difference between achievement levels of students in classrooms with IWBs and those which did not use such tools. Campbell investigated the effect of this technology on the achievement of fourth grade math students across gender, race and socio-economic status. A possible explanation for the lack of impact is that the teachers involved in the study used the technology merely as a substitute for a blackboard, or had minimal training in how to use such tools effectively.

Much research has shown that it is the teacher's approach and how the technology is used that makes a strong impact on student learning. A constructivist approach to learning is one of the keys to successful implementation of IWBs, as is adequate teacher training and technical support (Digregorio & Sobel-Lojeski, 2010; Yudt & Columbo, 2011). The school district participating in this study has encouraged its teachers to take a constructivist approach to teaching mathematics and to follow all other NCTM recommendations for best practices in teaching mathematics. Teachers in this district have also participated in several in-service trainings in cooperative learning and differentiating instruction, which are touted as best practices by NCTM (National Council of Teachers of Mathematics, n.d.). With the introduction of IWBs, teachers have had additional training in the most effective use of this technology. Rather than use it as a glorified chalkboard, teachers have learned how to engage students actively in the learning process and broaden their educational experience by incorporating content that otherwise would be difficult to convey. This study examined classrooms which utilize a constructivist approach to learning, active student engagement in lessons, and appropriate teacher training and support to maximize the impact IWBs have on student achievement.

Effectiveness of Computer-aided Instruction

Student achievement. To help improve the quality of education and to better prepare students for our technologically rich society, schools have invested large amounts of money in computers and other equipment. Simply providing access to computers is not a guarantee of an increase in student achievement, however. House (2007) performed an analysis of the relationship between computer activities and science achievement, using the TIMSS achievement test scores. He found that high scores on the science achievement test were correlated with frequent computer use at home and at school, especially when the computer was used for school work. Lower scores were correlated with frequent use of the Internet before or after school, or use of the computer for playing games before or after school. In this large national sample, the researcher found that a 7.3% variance of scores could be attributed to the type of computer use reported by the students. When used for academic purposes, therefore, House's research contends that computers can have a strong positive effect on students' science achievement.

By contrast, in a recent dissertation conducted by Davis (2012), no significant difference was found in fifth grade students' achievement after using instructional technology. Even though the computers were used for academic purposes, the students' learning in math and science as measured by the 2010 and 2011 Criterion Referenced Competency Test scores in science and math did not increase significantly more than the scores of those in the control group. The same teacher instructed both the control and treatment groups which would control for many extraneous factors.

One possible explanation for the lack of difference was that students were not motivated by the Web 2.0 technology since it was readily available in the school system in which the study took place. This novelty effect of using resources such as this can wear off and the effects can weaken. This theory is supported by the study conducted by Tienken and Maher (2008) in which students used computer-aided instruction for drill and practice in math. This study, too, showed no significant difference in achievement between treatment and control groups after using Web 2.0 technologies for their regular math instruction.

Another possible explanation is that Davis's (2012) study included a relatively small sample of 51 students. In addition, the teacher incorporated a constructivist approach to learning, but did not appear to differentiate for student learning needs, and this too could account for the lack of difference in test scores. Learning must occur within the child's Zone of Proximal Development and be geared to meet the learning style preference of the student in order for instruction to be most effective (Huebner, 2010; Powell & Kalina, 2009).

In addition to the purchase of computers and other technology equipment, a considerable amount of money has been spent on software programs and teacher training. Research has shown that this investment pays off in terms of student achievement. In a meta-analysis conducted on the effects of computer technology use over the last two decades, Qing and Xin (2010) found a moderately high positive effect of using computer technology on student achievement in math. The two most significant findings included large effect size for positive growth in math achievement for special education students and a small effect size for elementary students in general. They also reported that the three factors significantly influencing the effectiveness of the computer technology included special needs students, elementary classrooms, and a constructivist approach to teaching. Another study regarding the effect of Logo-Writer, a math software program, shows that the teacher's use of discovery learning was the key in helping to improve student problem-solving skills (Tyler & Vasu, 1995).

Another meta-analysis conducted in Taiwan found similar results. Yuen-kuang, Huei-wen, & Yu-wen, (2007) synthesized the results of 48 studies comparing computer application instruction, (which they define as computer-assisted learning, computer simulation, and Web-based learning) and traditional instruction. They, too, concluded that use of computer technology had a moderate positive effect on student achievement for elementary students. Neither of these studies addresses the idea of student motivation for using the technology, nor is the achievement of higher ability students mentioned.

In Florida, a research initiative called "Leveraging Laptops" was implemented in 11 school districts. In this initiative, schools received laptops at a one-to-one ratio so that every student had access to a computer at any time during the school day. Researchers studied the conditions in which the laptops were used, the processes the teachers implemented, and the effect on student achievement. Seventy-eight percent of the teachers in the study reported, "… changes in student achievement including test scores, higher level thinking skills, retention, and transfer of learning" (Cavanaugh, et al., 2011, p.369). The researchers also measured depth of learning by the number of inquiry-based lessons that were implemented, which rose significantly from the beginning to the end of the study (Cavanaugh, et al., 2011).

Cavanaugh et al.'s (2011) other significant findings were in the process of using the computers; and they support the earlier mentioned key factors of providing professional development, support and technology resources. All teachers involved in the program attended a four-day summer institute focused on the integration of technology in their classrooms. In addition, each district created a professional development program designed to meet the needs of the teachers, and implemented systematic support for the classrooms. These processes varied widely from district to district and the researchers believe this influenced the effectiveness of the implementation (Cavanaugh, et al., 2007).

Many studies show the effectiveness of computer-assisted instruction with at-risk elementary students, especially in reading. For example, Saine, Lerkkanen, Ahonen, Tolvanen and Lyytinen (2011) have found that computer-aided instruction was more effective than traditional methods of intervention in helping at-risk seven-year-old students to learn letter-sound relationships and decoding skills. In a similar study Volpe, Burns, DuBois, and Zaslofsky (2011) found that computer-aided instruction helped at-risk kindergarteners to learn letter recognition and to begin developing letter-sound associations. Additionally, computer-aided instruction was found to be actually more effective and more efficiently implemented in a small group setting than the traditional one-on-one tutoring usually used with first graders who are struggling in learning to read (Chambers, et al., 2011). Are these results transferrable to math and applicable to whole class use to better meet the needs of all learners?

Computer integration has also been shown to help students develop a deeper understanding of the content. In one study, researchers implemented a problem-based learning approach which followed the constructivist theory. They provided fourteen fourth grade students with Tablet PCs to use for practice sessions for learning estimation skills instead of the traditional paper and pencil method used by the other students.

Results showed that the experimental group had a stronger grasp of the concepts of rounding and could apply the strategy to real world examples more accurately than the control group. Students were found to be more willing to change their thinking and show their work on the e-sticky pads, possibly due to the novelty of such tools (Yu-Ju, Yao-Ting, Ning-Chun, Chiu-Pin, & Kuo-En, 2010). Sinclair and Crespo (2006) found similar results in depth of student learning using Geometer's Sketchpad. They, too, found that the use of technology helped students to learn complex, important math concepts. The three significant factors for improving student achievement, according to Sinclair and Crespo (2006) were visual actions in the program which emphasized the math concept, connections between math topics, and student communication of math processes (Sinclair & Crespo, 2006). Flexibility in thinking and willingness to explain the process are both critical elements in developing deep understanding of content.

A meta-analysis of computer-aided instruction and its effect on elementary students' achievement was conducted by Christmann and Badgett (2003). They examined 39 studies which compared the effect of computer-aided instruction and traditional teaching methods. In order to be included in the analysis, the study had to (a) be conducted in a school setting, (b) report empirical statistical data, (c) use experimental, quasi-experimental or correlational research designs, and (d) include at least 20 students in the experimental and control groups. Their results showed that the overall effect size was .342 for computer-aided instruction influencing higher achievement. According to Cohen's scale, this is a relatively small effect size. Christmann and Badgett (2003) did not address what subjects were examined in terms of computer-aided instruction, so again further discovery is needed to determine if this effect size would be consistent with elementary math students.

Another meta-analysis of technology applications and their effects on reading achievement showed minimal positive impact on K-12 students' learning. Studies in which teachers were provided with professional development and practice in using the technology, however, showed a lot more promise in helping to increase student proficiency (Cheung & Slavin, 2012).

As Vygotsky proposed, a constructivist approach to learning and student communication during the learning process leads to increased understanding and achievement (Powell & Kalina, 2009; Vygotsky & Kozulin, 2011). Yikin (2011) also found that implementing discovery learning and student communication of the math process were two of the major influencing factors in raising student achievement when using computers. He designed a study in which fourth and fifth graders used a Personal Digital Assistant (PDA) for learning math. These devices are much cheaper to purchase than a laptop or desktop and are able to perform essentially the same functions. The fifth graders in the treatment groups used the devices to learn fractions while the control groups received traditional instruction. The students in the treatment group used the *notes* function on the PDA to solve problems involving fractions and then sent them wirelessly to a partner to confirm the answer was correct. The mean score on a final test on fractions for the treatment was 10.10 points higher with an effect size of .303, which is not statistically significant.

The fourth graders in the treatment groups used the PDA to learn Least Common Multiple (LCM) while their fourth grade counterparts in the control groups learned the same concept using traditional methods (Yikin, 2011). The teacher of the fourth graders in both control and treatment groups used discovery learning and partner work in which the students were required to explain their answers instead of simply sharing them as the fifth grade groups did. The treatment groups mean score was 41.05 points higher with an effect size of 1.443. These results are statistically significant and indicate that the instructional approach does indeed impact students' learning with technology. This study aims to use the constructivist approach to learning and also encourage student communication throughout the learning process.

Cheung and Slavin (2011) also conducted a meta-analysis of the effect of technology on math achievement of K-12 students. They reviewed 74 studies in which technology use fell into one of three categories: (a) computer-managed learning, in which students are leveled and provided practice at that level, (b) comprehensive models which combine computer use with the students' approach to learning mathematics, and (c) supplemental technology designed to provide students with additional practice at their individual levels after instruction. While each application had a positive effect, the supplemental approach had the largest impact on student learning. This supplemental approach is being implemented in this study using Study Island software and is proposed to have a positive impact on students' learning.

One other aspect of computer-assisted instruction to consider is the quality of the software that is utilized. Oftentimes software programmers focus more on the specialized aspects of the program and do not always hit the mark with the intended learning outcomes. Lindstrom, Gulz, Haake, and Sjoden (2011) labeled this a mismatch between intention and design of the software and the actual way students use the program.

Independent studies using content specific software have shown mixed results. Maloy, Edwards, and Anderson (2010) implemented a web-based tutoring program with fourth grade students which resulted in higher achievement in 70% of all participating students. The teachers in the study incorporated a program called 4MALITY once a week into their fourth grade math classes. Researchers from the University of Massachusetts Amherst designed 4MALITY to help prepare 4th grade students for the Massachusetts state achievement test. The program aims to promote inquiry learning and problem solving skills. It utilizes online tutors who provide the students with hints for how to solve the problems as needed. The researchers calculated a t value of -12.58 which indicates highly significant achievement gains from pre-test to post-test (Maloy, et al., 2010). The results should be viewed with caution, however, since there was no control group used in the study and there are many other possible explanations for the positive results for the students, such as the novelty effect.

Another study conducted regarding the effectiveness of a software program called Wayang Outpost showed positive results in math achievement in middle school students. The researchers examined the software which was designed to improve the students approach to problem solving as well as increase their math fluency. Their findings support the theory that increasing a student's math fact fluency frees the working memory of the brain so that the student can focus on how to correctly solve the word problem presented (Aleven, Kay, Arroyo, Royer & Wolf, 2011). Part of the focus of the Study Island software being used in this study, is to help students understand the process of solving problems, as well as to give them practice in math fact fluency.

Another web-based software program called Odyssey Math was examined for its effectiveness in helping to raise achievement in fourth grade students. This study revealed no significant difference in student achievement at the end of the school year. One possible explanation for this lack of positive effect was the amount of time students spent using the program. The authors recommended using it for 60 minutes per week to supplement math instruction, but actual time of usage was closer to 38 minutes per week on average (Wijekumar, Hitchcock, Turner, Lei, & Peck, 2009). An interesting contrast is the time spent in the study using 4MALITY. The fourth graders in that study used the program once a week during their regular math class and still showed significant gains in math achievement (Maloy, Edwards, & Anderson, 2010). Another study in which time spent was a significant factor was conducted by Sunha and Mido (2010). They examined the math achievement of fourth graders, looking at the time spent playing math games and gender of the student. They discovered that male students who sometimes play math games showed higher achievement scores on a standardized math assessment than students who played never or every day. No significant difference in achievement was found for girls based on time spent playing math games. This shows that schools need to determine the quality of the software program and the ideal amount of time needed in order to effectively utilize the program.

The FCAT (Florida Comprehensive Assessment Test) Explorer is another web-based program designed to help student performance on Florida state standardized tests (Martindale, Pearson, Curda & Pilcher, 2005). A significant difference in achievement scores was found for elementary students using the program versus students who did not, but no significant difference was found in high school student scores. Some key factors in the effectiveness of the software are the ability to differentiate practice for students of all abilities, and the emphasis on making connections between known information and the unknown (Hadjerrouit, 2011; Sinclair & Crespo, 2006). The software being examined in this study is designed to help improve student performance on state standardized tests as well. This study intends to contribute to the literature in these areas.

Student motivation. Another important reason for incorporating computer-aided instruction in the classroom is to increase student motivation which can, in turn, raise achievement levels. One meta-analysis regarding the link between student attitude and achievement was conducted in the area of reading. After examining 32 studies on the relationship between attitude in reading and reading achievement, Petscher (2010) found a moderate effect size overall, with a stronger effect size evident in the elementary students. A larger effect size in the elementary students indicates that helping students to form a positive attitude toward the subject at an early age is important to motivate them to succeed at the highest level possible.

In regard to the link between attitude and achievement in math, research is limited. Di Martino and Zan (2009) propose that there is a three-dimensional view that should be considered when examining student attitude. This view consists of the interconnected ideas of the emotional dimension, the student's vision of mathematics, and the student's perceived competence. This insight combined with results of other studies can assist teachers in helping students improve their understanding of math and their perceived competence so that they then have a more positive outlook. Computers are one tool which teachers can use to do this.

One study conducted by House and Telese (2011) with eighth grade math students in the United States and Korea aimed to find a connection between computer activities, classroom teaching strategies and student motivation. From survey data gathered from a large sample of over 10,000 students, they determined that students who use computers for schoolwork in math also reported that they enjoyed math. Furner and Marinas (2007) found that by incorporating a software program for geometry with elementary students, the children took an active role in learning. The software also helped them to connect concrete examples to the more abstract concepts of geometry. In regard to motivation, students reported that the program was fun and easy to use (Furner & Marinas, 2007).

In a similar study, fifth, sixth and seventh students in the Bronx were given the opportunity to lease a laptop for a minimal fee (Zardoya & Fico, 2001). The program required an orientation with parents, teachers, and administrators. It also provided teacher training in the use of the technology in a standards-based curriculum. Results of the study showed an increase in student attendance, parent involvement, and student motivation. All of these aspects of learning follow the recommendations of NCTM for best teaching practices in math.

Reed, Drijvers, and Kirschner (2010) also conducted a study in which computer-aided instruction was employed to help students develop their concept of function in mathematics. Using a large sample of 521 students, researchers employed a constructivist approach to learning using the computer program, while also encouraging students to talk through the mathematical processes. They found that a positive attitude toward math tended to increase a student's engagement in the learning process which in turn increases achievement. In fact, the researchers claim that a 3.4 point difference in achievement levels on a ten point scale could be attributed to the students' attitude. Although the results must be taken with caution since the study was conducted in the Netherlands and the same conclusions may not be evident with students in the United States, this demonstrates again how important it is to help students develop a positive attitude toward math and that this may be accomplished using computers.

Dresel and Haugwitz (2008) also designed a study to help improve student motivation and self-regulation in learning. In their research, these authors used three groups of participants: one group used a software program that gave attribution feedback, one group used this same software program and also received self-regulation training, and the control group received neither treatment. They found that the first group did have statistically significant positive changes between the pre- and post-test in attitude. In addition, the second group which also received the cognitive training showed similar positive attitudinal changes, but they also demonstrated better knowledge acquisition. The implications for the classroom teacher, then, is to use software which provides specific feedback and couple this with other meta-cognitive learning activities for the strongest effect on attitude and achievement.

Study Island software, the use of which is being examined in this study, meets the suggested ways that technology can be most effectively. This program uses specific feedback in that it shows the students immediately if the answer if right or not. It also gives the correct answer if the student goes back to review problems missed. The lesson component of the software offers direct instruction so the student can understand the concept. Most lessons consist of a video in which cartoon characters use humor and real-life situations to convey the important elements of the topic. The software is also designed so that teachers can differentiate instruction. Options include setting a student on a lower or higher grade level to study the topic being covered, offering text-to-speech for students with reading difficulties, and setting the number of answer choices for the students. The colors, graphics, and game mode can also be very motivating for students of all levels.

A recent dissertation completed by Hunter (2012) examined the effect of computer-aided instruction and structured curriculum on struggling math students. The effects of each approach showed no statistically significant results in achievement, and none of the approaches seemed to significantly impact students' attitude toward mathematics. The study incorporated three groups of students: one group used a standards-based computer program called SuccessMaker, the second group used a structured curriculum approach, and the third group incorporated both SuccessMaker and structured curriculum. Each group received instruction and practice from the researcher in what was expected during the eight-week study, but several teachers did not implement their component as directed. One of the structured curriculum teachers used peer tutoring instead of the prescribed curriculum, so this may have altered those results. In addition, the groups who implemented SuccessMaker did not always provide direct instruction or use a constructivist approach to learning which would make the use of computers less effective.

In addition to these breeches in fidelity of implementation, there are two other factors which may have contributed to the insignificant differences among the groups (Hunter, 2012). One factor may have been the combination of student off-task behavior and technical difficulties exhibited by the computer-aided instruction group. If the students are not motivated to use the software, then the time spent on the computer will not be as effective for learning. Also, if the computers are slow to respond or the student cannot access the program, then the student will become frustrated and lose any motivation to use the program.

In addition, each group involved in the study was comprised of students identified as struggling in math (Hunter, 2012). Groups of students like this, even if they are not identified with a learning disability, often have a preconceived negative attitude based on their lack of success in math in the past. This negative attitude can impact their motivation and effort in math and thus ultimately impact their achievement (Petscher, 2010). This study intends to use heterogeneously grouped students and provide students with as much success as possible in both the treatment and control groups by differentiating instruction and working to meet individual students' learning preferences which should help to increase student attitude and motivation, leading to increased achievement.

Conclusion

The elementary years are crucial for setting a child on the road to a love of learning and academic success. This is why appropriately challenging and motivating instruction is important to implement. In addition, fifth grade students in Pennsylvania are required to take the state mandated standardized tests. While there have been advances in test scores over the last five years, there still remains a population of students who struggle to master the grade level content as evidenced by these tests. At the same time, there are many students who exceed grade level standards easily. They, too, need to be challenged and given the opportunity to excel. Students also need to learn to set goals for themselves and work diligently to achieve to their highest potential. Examining the current teaching that is in place, as well as computer-aided instruction, will help classroom teachers to make more informed decisions about how to most effectively teach all students and inspire them to become lifelong learners. It will also influence decisions at a district level regarding the best use of limited funding for technology.

CHAPTER THREE: METHODOLOGY

Due to the stringent requirements of *NCLB*, and a desire to best meet the educational needs of the diverse students in today's classrooms, teachers need effective instructional methods. Traditional classroom instruction has been successful to a point, but many students still fail to master the academic standards, especially in math. By the fifth grade, too, many students have lost their motivation and excitement in learning which, in turn, effects achievement. With the increased availability of software and technology in schools, teachers are searching for the most effective way to incorporate these resources to improve the achievement of all students, while also increasing their desire to learn.

This study was designed to measure the effects of computer-aided instruction in mathematics on fifth grade math students. The treatment consisted of students receiving direct instruction in math, supplemented by an additional twenty minutes of guided and/or independent practice using a software program which provides immediate feedback, is self-paced, and is designed to meet the individual needs of the students. Data were collected to determine if there was an attitudinal difference in the groups using the computer-aided instruction, as well as a difference in achievement of both low and high achieving students. This chapter aims to describe the experimental design, dependent and independent variables, student sampling procedure, as well as data collection and analysis. A proposed timeline is also included.

Research Design

This study incorporated a quasi-experimental nonequivalent control group design. This research method was chosen because the study intended to collect and analyze empirical data regarding the effects of computer-aided instruction on students' attitude and achievement as it compares to the effects of traditional instructional methods (Gall, Gall, & Borg, 2003). There was no random assignment of students to treatment. Instead, intact groups of students were used so as to not disrupt the school's system of classroom assignment. This system included a careful analysis of students' individual needs. Efforts were made to balance classes based upon students' academic, social, emotional, and behavioral abilities and needs. The number of students in each class was as equal as possible, as was the number of boys and girls. For the purpose of this study, classes were randomly assigned to either treatment or control, with each participant taking a pre-test, a mid-term test, and a post-test to measure math achievement (Gall, et al., 2003).

The treatment groups used computer-aided instruction to supplement the fifth grade math curriculum while the control groups used more traditional methods to meet the learning needs for both low-achieving and high-achieving students in fifth grade. The computer-aided instruction was incorporated three days out of a six-day cycle. Math instruction continued to be provided daily for both groups.

To measure attitude towards math, all students were given an attitudinal survey at the beginning of the study. This survey was given again in the middle and the end of the study to determine if there was any difference that could be attributed to the treatment. Effects were measured across the two achievement levels of students, high-achieving and low-achieving. The instrument used was an adapted version of the Mathematics and Technology Attitudes Scale (MTAS) developed by Pierce, Stacey, and Barkatsas (2005).

The second factor to be measured in the study was the achievement level of the student receiving the treatment. Students were categorized as low-achieving or high-achieving in math based on the following criteria: (a) level of proficiency on the fourth grade PSSA math test, and (b) the results of the 4Sight math test, Form 2, from fifth grade given just prior to the beginning of the study. This research design allowed for a powerful analysis of the scores of students identified as low-achieving and those identified as high-achieving across both conditions.

Research Questions and Hypotheses

The research questions posed in this study are as follows:

1. How do the scores of the 4Sight Math assessment differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

2. How do the scores of the 4Sight Math assessment differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

3. How do the scores of the 4Sight Math assessment differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

4. How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

5. How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between low achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

6. How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between high achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

The null hypotheses are as follows:

H_1: There will be no statistically significant difference between 4Sight scores of students receiving computer-aided instruction using a standards-based software program and students receiving traditional instruction utilizing an IWB.

H_2: There will be no statistically significant difference between 4Sight scores of low-achieving students receiving computer-aided instruction using a standards-based software program and low-achieving students receiving traditional instruction utilizing an IWB.

H_3: There will be no statistically significant difference between 4Sight scores of high-achieving students receiving computer-aided instruction using a standards-based software program and high-achieving students receiving traditional instruction utilizing an IWB.

H_4: There will be no statistically significant difference between MTAS scores of students receiving computer-aided instruction using a standards-based software program and students receiving traditional instruction utilizing an IWB.

H_5: There will be no statistically significant difference between MTAS scores of low- achieving students receiving computer-aided instruction using a standards-based software program and low-achieving students receiving traditional instruction utilizing an IWB.

H_6: There will be no statistically significant difference between MTAS scores of high-achieving students receiving computer-aided instruction using a standards-based software program and high-achieving students receiving traditional instruction utilizing an IWB.

Participants

The students in this study were 91 fifth graders in a small, rural school district in south-central Pennsylvania. To participate, subjects must have attended school in the district for the duration of the study. If students had moved out of the district, they would have been eliminated from the study, but if they would have transferred within the district and if they had been placed in a classroom receiving the same treatment or control as they originally came from, they would have remained in the study. No students, however, moved or transferred during this study. This sample size exceeded the recommendations for this research design of at least 30 subjects in each group, to allow comparison between the treatment and control groups, considering the two levels of achievement (Gall, et al, 2003). The larger number of students also allowed for attrition throughout the study. These students were chosen based on their proximity and availability to the researcher. In addition, this school district has the internet capability and other equipment needed to support the technology aspect of the study.

The targeted children were between the ages of 10 and 11 years old, and include an approximately equal number of boys and girls. The ethnicity of the group is 95% Caucasian, 2% African American, 1% Hispanic, 1% Asian, and 1% Native American. There are five students currently identified as learning disabled and one English Language Learner. Approximately 40% of the students qualify for the free or reduced lunch program.

Each student was assigned to a classroom by an instructional team, which included their core and support teachers from the previous year as well as the school principal. The team attempted to equalize the classes according to achievement level, special needs, gender, and other demographic features. There were three fifth grade classes in one of the elementary schools and two in the second elementary school in the district. Each class was randomly assigned to treatment or control. Three classes were assigned to computer-aided instruction and two were designated as control for the first seven weeks of the study. For the second period of seven weeks, the treatment groups became control and the control groups received the treatment. This procedure was used to help to control for variances in teacher experience, as well as other individual teacher differences that may affect student attitude and achievement.

Setting/Demographics

A small, rural school district in south-central Pennsylvania was chosen for this study. The primary industry is agriculture, but the area supports a variety of other businesses as well. The district is comprised of two elementary schools, one middle school and one high school. The elementary schools house students in kindergarten through fifth grade. Approximately 850 elementary students attend school in this district, with each elementary building housing around 300 and 550, respectively. Student population shows very little diversity with 95% of the students being Caucasian. Approximately 40% of the students qualify for free or reduced lunch according to federal guidelines.

The school district uses a traditional math curriculum currently. The software Study Island is available for teacher use, but is implemented on a very limited basis. A typical class uses the program for 40 minutes for math practice once every 12 days. Each elementary classroom has a variety of technology resources including the following tools: a Promethean interactive board, a laptop for the teacher, four computers for individual student use, and a computer lab for whole class use which must be scheduled in advance. Carts of laptops are also available for classroom use, and a wireless infrastructure allows for Internet use in each classroom. Use of each technological resource varies from teacher to teacher, but no one uses Study Island more frequently than previously stated. No other standards-aligned computer programs are used on a regular basis for math instruction.

Instrumentation

Two different instructional methods were the independent variables in this study. One method incorporated traditional teaching methods, which included the use of an IWB. The other instructional method included the use of a standards-based software program called Study Island. To measure the effect of each method on the students' attitude and achievement in math, two instruments were used.

To measure math achievement, the 4Sight Mathematics assessment was used. This assessment is currently used district-wide in the aforementioned school district in third through eleventh grade. It is a standardized, criterion-referenced assessment which is used as a predictor score for the Pennsylvania System of State Assessment (PSSA), the state mandated test. This test has five forms at each grade level, allowing the assessment to be given multiple times during the school year. At the elementary level, the test encompasses what is to be covered in the given grade's curriculum. In fifth grade this includes topics such as number sense, place value, fraction concepts, reading charts and graphs, and various problem-solving skills.

According to the Pennsylvania Training and Technical Assistance Network, the 4Sight Assessments are, "…valid, reliable and aligned to the PSSA and provide an estimate of student performance on the PSSA… "(Information obtained from PaTTAN.net). This assessment is highly recommended by the Pennsylvania Department of Education as a tool to guide instruction in reading and math for all students in grades three through eleven. According to an article entitled "4Sight Correlation Updates" published by the Success for All Foundation (2008), the correlation of scores from the 4Sight Assessment with the PSSA scores is established using a linear regression model, matching individual student scores on each test. These correlations are reportedly calculated each year; however, the most current statistics available are from 2008. At that time, the level of correlation for the math assessment ranged from .86 to .91 (4Sight Correlation Updates, 2008). In addition to the establishment of these correlations, an item analysis was conducted to ensure questions were valid and distribution of scores was studied to ensure it is a normal distribution. These claims have been confirmed in a study conducted by Daniel Robert Castagna (2008) whose dissertation also showed a strong correlation between results of the 4Sight Assessment and the PSSA scores for students in grades six, seven and eight.

The Success for All Foundation applied the Pearson Correlation procedure to determine the reliability of the assessment in 2006-2007 using data from the various schools administering the 4Sight test. For fifth grade math, the reliability coefficient was 0.79 (N=21,200), thus making this an appropriate instrument for this study (Pennsylvania State Education Association, 2007).

The second instrument being used in this study was the Mathematics and Technology Attitudes Scale (MTAS) developed by Pierce, Stacey, & Barkatsas (2007). This survey was developed for use with middle school aged students to evaluate student attitude in five categories of affect: (a) math confidence, (b) technology confidence, (c) attitude toward learning math with technology, (d) affective engagement in math lessons, and (e) behavioral engagement in math lessons. Pierce et al. (2007) extrapolated data from 350 students' responses to evaluate the 20 survey items and found, "… that this satisfies the assumptions of the Principal Components Analysis and that together five factors (each with eigenvalue greater than one) explain 65% of the variance..." (p. 294). An analysis of each subscale revealed Cronbach's alpha values ranging from .65 to .89 which again shows an acceptable level of reliability for the use of this instrument. Permission for use of this survey was granted by Elsevier (see Appendix A).

Data Gathering Methods

The school administrators granted permission to conduct the study using all fifth grade students as participants. Permission was also granted to meet with teachers regarding implementation procedures, to collect assessment data from each form of

4Sight administered from January to May, and to administer an attitudinal survey to each student at the beginning, middle, and end of the study. Recruitment letters, parent/guardian consent letters, and child assent forms were sent home to students for parental and student consent before the implementation of the study (see Appendices B, C and D). In addition, approval from the committee chair was granted, and the Institutional Review Board gave their permission to use human subjects in the study.

Teacher training. At the beginning of the school year, the researcher met with the fifth grade teachers to discuss the details of the intended study. Teachers gave input regarding scheduling of math lessons and lesson plan format. All teachers were required to instruct in math for the same amount of time each day and to submit lesson plans in a similar format which included objectives, procedures, assessments and how differentiated instruction was provided. The treatment group was required to include on their weekly lesson plan which topic of Study Island was assigned each day and the adaptations made for individual students. After teachers were randomly assigned to either treatment or control, a workshop was conducted by the researcher regarding the specific methods required to implement Study Island into the treatment groups' supplemental lessons. Topics covered included: (a) using 4Sight results to differentiate lesson assignments in Study Island, (b) setting Study Island preferences to best meet the needs of each learner, (c) assigning students to appropriate levels and modes of learning on Study Island, (d) helping students set goals for each topic, and (e) giving students an incentive of using the game mode of practice if they met the set goal. Teachers were required to use the Study Island software with all students in the treatment group for 20-30 minutes three days out of a six-day cycle as a supplement to the regular math instruction provided. The control group did not receive the workshop until right before they become the treatment group, but were encouraged to use 4Sight results to differentiate instruction using traditional methods.

Classroom observations and lesson plan collection. To ensure fidelity in teacher compliance to study guidelines, random classroom observations were conducted by the researcher and the district computer support person. Observation notes include the lesson topic covered, the activity in which the students were engaged, and how the lesson was differentiated to meet individual learning needs. Lessons plans were collected weekly and reviewed by the researcher and building principal to ensure they comply with study and district guidelines.

Study Island reports. Various reports from Study Island were printed to track student activity. Reports included the following information: (a) time each child spent using the program, (b) topic practiced and in what mode (test or game), (c) modifications allowed (such as text-to-speech or grade level adjustment) and (d) student scores earned on each topic. Information from the Study Island website was gathered by a research assistant who removed all names from the reports and used the students' identification number to ensure confidentiality and to prevent any researcher bias.

Baseline, mid-term and post-test for math achievement. In order to obtain a baseline score, all fifth grade students were given the 4Sight Math assessment (Form 2) in January, right after Christmas vacation. This data, combined with other data collected were used to categorize students as high-, low- or average-achievers in math. Low-achieving students were defined as students who score in the basic or below-basic range on the fourth grade PSSA math assessment and who score in the basic or below-basic range on the 4Sight math assessment (Form 2). High-achieving students were defined as those who score in the advanced range on the fourth grade PSSA math assessment or those who score in the advanced range on the 4Sight math assessment (Form 2) with no score below the proficient level. All reports collected by the researcher in regard to the fourth grade PSSA reports and 4Sight math assessment data were prepared by the building principals and research assistant. Reports given to the researcher had no names attached; only identification numbers were used to indicate individual students.

Teachers in the targeted district have been giving this assessment for the past five years. To ensure that proper testing procedures are followed, however, the researcher reviewed administration rules with each teacher before the first test was given with reminders repeated before the subsequent testing dates. All students were given the same directions that are printed in the administration manual and had one hour in which to complete as much of the test as possible. Help with words in the questions was permitted, but no assistance with concepts was permitted. The only interaction the teacher was to have with the students was to clarify directions..

The math test contained an open-ended section in which students were asked to show and explain their work in writing. This section was scored by the classroom teacher. The rubrics provided in the answer key for this section of the 4Sight are very specific and, therefore, limit the possible interpretations of student responses and reduce scorer bias. To ensure inter-rater reliability, the researcher and a math instructor from outside the district who was trained in scoring the assessment reviewed the open-ended responses. Discrepancies with the teachers' scores were discussed with the individual teachers and scores were modified as recommended.

This same assessment, in different forms, was given to students in February after the first round of treatment and then in May after the second cycle of treatment. The same procedures for validity and reliability were repeated in February and in May to ensure consistency. Results were then analyzed to determine any gains in achievement.

Baseline, mid-term and post-test for attitude toward math. Also in the beginning of January, an attitudinal survey was given to all fifth graders to determine a baseline of attitude toward math before treatment was implemented. The researcher met with each fifth grade teacher to give directions as to how to administer the survey to ensure the same instructions and procedures were followed in each classroom. Again, to protect the privacy of the students and to prevent researcher bias, students used only their identification number on the survey. The same survey was administered in February at the middle of the study, and in May at the conclusion of the study. Results were examined to determine any change in attitude that can be attributed to treatment.

Data Analysis

This study was designed to compare the effect of computer-aided instruction and traditional instruction for both low- and high-achieving math students in fifth grade. A baseline achievement score was determined by the 4Sight Math assessment (Form 2). Descriptive statistics were calculated from this data to determine the mean scores of the control group and the computer-aided instruction group. Mean scores for the low-achieving and high-achieving groups were also calculated for each group. To determine the achievement gains for each group, the mean scores of the differences from pretest to posttest were also analyzed.

After administering the subsequent two math assessments, descriptive statistics were calculated resulting in mean scores for each group. At the end of each phase of the study, a repeated measures analysis of variance (ANOVA) was used to measure achievement gains, factoring out any pre-existing difference between groups. This provided information regarding any significant differences in achievement in groups due to the treatment. If the F value was significant, then the mean scores of the differences in scores from pretest to posttest for each group were analyzed to determine where significant statistical differences may lie.

Descriptive statistics was also used to determine any significant differences in attitudinal scores between students in the computer-aided instructional group and the control group. Again, repeated measures ANOVA was employed to determine if any significant differences existed between the groups' scores. As with the achievement assessment, the mean scores of the differences in scores from pretest to posttest were examined to determine any statistical significant gains or losses. A *t* test was then used when appropriate to determine any significant differences between specific groups that could be attributed to treatment. Scores were also examined based on level of achievement. Repeated measures ANOVA and a *t* test again when appropriate were used to show if any significant differences exist between high-achieving and low-achieving students in terms of attitude towards math.

Based on the information derived from statistical analysis, the researcher reached several conclusions. First, although the results showed limited overall differences between the groups receiving traditional instruction including an IWB or computer-aided instruction, they still provided implications for instructional practices for all students. In addition, the findings led to recommendations for further research in this area.

CHAPTER FOUR: FINDINGS

This chapter includes the intended purpose of the study, the chosen method of data analysis, the research questions and hypotheses, and the results of this study. The chapter also contains the results of the data collection and a full statistical analysis. SPSS software was used to run the statistical analysis. The dependent variables examined in this study were the 4Sight Math assessment scores and the Mathematics and Technology Attitude Scale (Pierce, Stacey, & Barkatsas, 2007) scores. The independent variables were the two modes of supplemental math instruction which was provided three times per six-day cycle for twenty minutes each time: the use of Study Island software, and traditional instruction which included the use of Interactive Whiteboards.

Purpose of the Study

The purpose of this quasi-experimental nonequivalent control group designed study was to measure the effect of computer-aided instruction on fifth grade students' attitude and achievement in math, and to add to the literature regarding its effectiveness with students of all ability levels. Much research has been conducted regarding the use of technology and its effectiveness with today's learners (Blue & Tirotta, 2006; Cavanaugh, Dawson, & Ritzhaupt, 2011; Dreon, Kerper & Landis, 2011; Dunleavy, Dexter & Heinecke, 2007; Frye & Dornisch, 2008; Manny-Ikan, Tikochinski, Zorman & Dagan, 2011). The school district in this study has invested considerable time and resources in providing its teachers and students with the infrastructure and equipment to support the use of various technologies. It has also invested money in various software programs, such as Study Island, and it is in the best interests of all to gather as much information as possible regarding its effectiveness with all students.

Study Overview

The study was conducted in a rural school district in Pennsylvania whose total elementary school population is approximately 800 students in kindergarten through fifth grade. The population studied included all students enrolled in the five fifth grade classes. The study was conducted in two phases which produced a counterbalanced study. During the first seven-week phase, fifth grade teachers were randomly assigned as either treatment or control and during the second seven-week phase, teachers were assigned to the opposite instructional method. All students received regular math instruction daily. The treatment group was to receive supplemental instruction using Study Island for twenty minutes three days of the six-day cycle while the control group was to receive supplemental instruction using traditional teaching methods for the same amount of time over the six-day cycle.

Data Analysis and Methodology

Repeated measure ANOVA was initially used to analyze the differences between the mean scores of the control group and the mean scores of the treatment group on the math achievement measure and the attitude survey. The SPSS software program was employed to run the analysis. The repeated measures ANOVA is appropriate to conduct with the collected data because this calculation separates subject differences due to treatment from differences due to error or pre-existing differences (Howell, 2008). Howell (2008) states that this statistic requires the "… assumptions of normality and homogeneity of variance required for any analysis of variance" (p. 451). Further, according to Howell (2008), the *t* test is commonly used to measure the difference between the means of two independent samples. In an explanation of when the *t* test is appropriate to use, Kokoska (2006) states, “As long as the underlying population is normal, this test is valid (and exact) for any sample size *n* (large or small)” (p.500). An assumption required to use both tests is the equal variance of populations. This means that a population would be expected to differ somewhat based on a variety of circumstances such as maturity, growth, and experience. When a treatment is given, therefore, it is assumed that the groups’ variances will remain constant. If, however, the variance of one group is shown to be significantly different from the other then the variance can possibly be attributed to the treatment (Howell, 2008).

According to the Empirical Rule, if the shape of the distribution of scores from a set of observations is approximately normal, then, “the proportion of observations within one standard deviation of the mean is approximately 0.68” (Kokoska, 2006, p. 110). The scores of the 4Sight math assessment (Form 2) which was used as a baseline score for math achievement have an approximate normal distribution. Considering the Empirical Rule, 71.43% of the scores fall within one standard deviation of the mean of the whole group which satisfies the expectation that 68% of scores would fall in this range. This is shown in Figure 1.

In addition, when examining the scores from the initial attitude survey, 65.31% of the scores fell within one standard deviation of the mean. Extrapolating the scores further, 97.9% of the scores fell within two standard deviations from the mean, which again meets the requirement of the Empirical Rule which states that 95% of scores should fall within two standard deviations of the mean (Kokoska, 2006). Therefore, this distribution has an approximately normal distribution as shown in Figure 2.

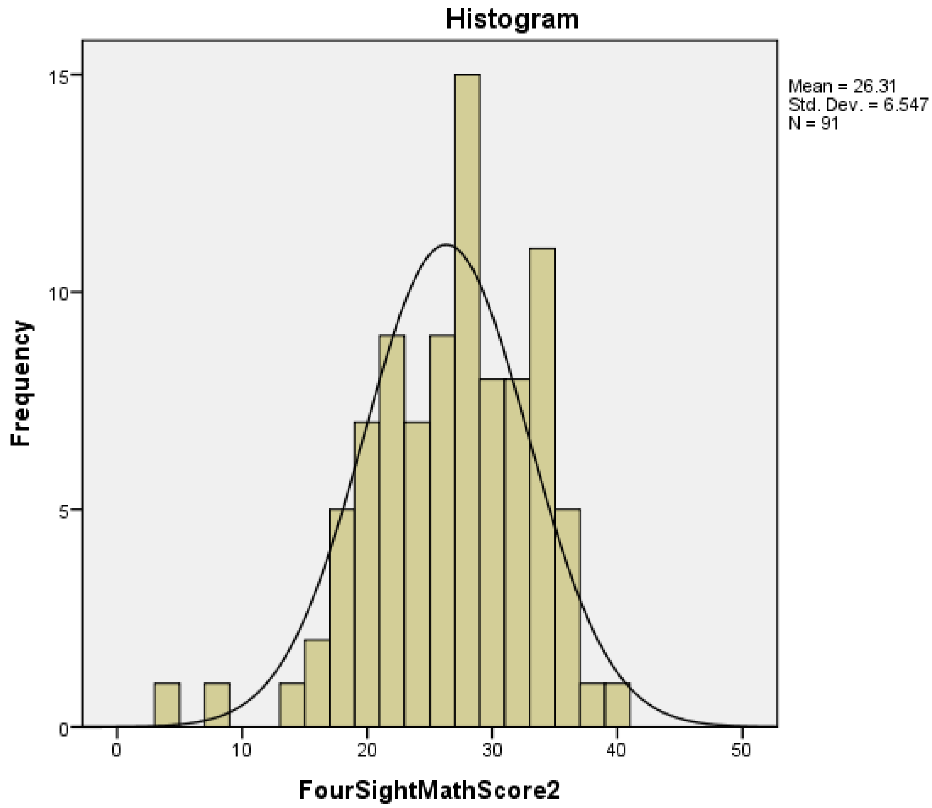


Figure 1: Histogram of 4Sight Scores from February (baseline)

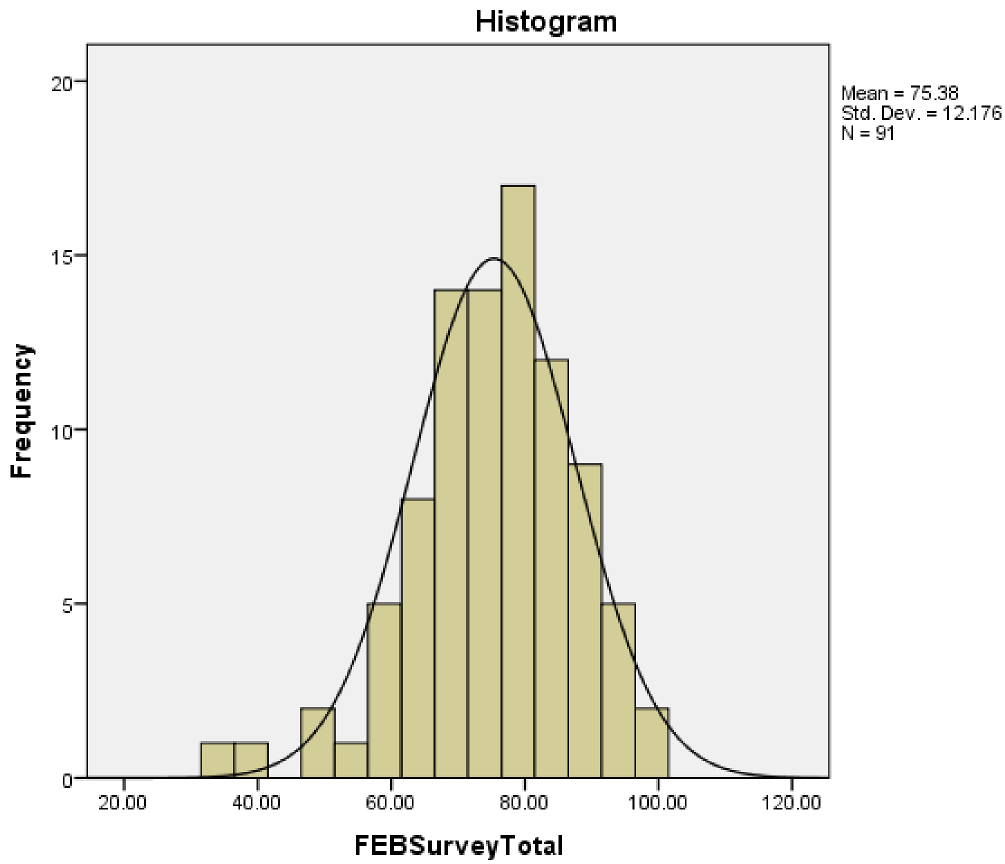


Figure 2: Histogram of Attitude Survey Scores from February (baseline)

Results from Phase One

Research Question 1: How do the scores of the 4Sight Math assessment differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

A total of 91 students participated in the study. These students were designated as control or treatment based on the random assignment of their homeroom, and then were classified according to achievement level as low-, average-, or high-achieving (see Table 1). The control group in phase one was comprised of 39 students: seven low-achieving students, 22 average students, and 10 high achieving students. There were 17 males and 22 females. This group received traditional supplemental math instruction. The treatment group in phase one consisted of 52 students: eight low-achieving students, 26 average students and 18 high-achieving students. In this group, there were 23 males and 29 females. These students received supplemental math practice using Study Island software. While the control group also used the program since it is part of the fifth grade curriculum, the time spent varied greatly (see Table 2). The students in the treatment group used the program for an average of approximately one hour and 29 minutes over the course of seven weeks. The actual time spent logged in to Study Island ranged greatly among the students in this group, with some students spending over three and one half hours during this phase to others spending a little less than 20 minutes actively working on the program during this same time period. Students in the control group, meanwhile, spent an average of 28 minutes and 57 seconds logged onto the program. Table 3 shows the average number of sessions in which the participants were logged in to Study Island, broken down by achievement group.

Table 1

Participants in Phase One

Group	Total Students	Low-Achieving Students	Average Students	High-Achieving Students
Control 1	39	7	22	10
Treatment 1	52	8	26	18
Total Participants	91	15	48	28

Table 2

Average Time Spent on Study Island in Phase One

Group	Total	Low-Achieving Students	Average Students	High-Achieving Students
Control 1	28:57	29.02	31:42	22:51
Treatment 1	1:29:07	1:34:37	1:14:39	1:47:33

Note. Times shown in hh:mm:ss

Table 3

Average Number of Sessions Logged in Study Island in Phase One

Group	Total Group	Low-Achieving Students	Average Students	High Achieving Students
Control 1	8.56	8.71	9.27	6.9
Treatment 1	18.27	21.25	17.58	17.94

The baseline data from the 4Sight Math assessment were graphed to check its shape for normality, and since the graph of the data (see Figure 1) is quite symmetrical, the data can be interpreted as approximately normal. A repeated measures analysis of variation (ANOVA) and a *t* test, therefore, were valid tests to use to compare the resulting data.

A repeated measures analysis of variance (ANOVA) was conducted using SPSS software to analyze this data to determine if any difference in mean 4Sight math assessment scores could be attributed to traditional instruction or Study Island treatment. This procedure factors out any error or naturally occurring variances in the population's mean scores. As seen in Table 4, the repeated measures ANOVA on the 4Sight math assessments Form 2 and Form 4 produced a statistically significant result, (F (1,90)=68.799, $p<.05$) with a p value of less than .0001. This shows that a significant part of the variance in scores can be attributed to something other than error, such as time, maturation, and test practice. This same analysis was run for the students in Control Group 1 with the results (F (1, 38) =44.559) and $p<.0001$, again showing that a significant effect on the students' mean scores was the teachers' math instruction. Interestingly, the analysis for Treatment Group 1 resulted in ($F(1,51)=28.217$) and $p<.0001$, which while still statistically significant, does not attribute as much effect on the variance of scores to treatment as the Control Group's results.

Since one purpose of this study was to determine which method had a bigger impact on students' achievement gains, the mean of the differences in scores of the 4Sight Math assessment from Form 2 to Form 4 for the Control Group 1 and Treatment Group 1 were compared. Results displayed on Table 5 show that the mean difference score for the Control Group 1 students (N=39) was 4.97 (SD= 4.65) while the mean difference score for the Treatment Group 1 students (N=52) was 2.90 (SD = 3.94). At $p = .0001$, the probability of the null hypothesis being false is high, so based on this data, the researcher rejected the null hypothesis H_1 which stated: there will be no statistically significant difference between 4Sight Math assessment (form 4) scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

An overview of the data in Table 4 shows the initial test scores differed by approximately two points, with the Control Group 1 starting out at 25.28 (SD = 7.16) and the Treatment Group 1 beginning at 27.08 (SD = 6.00). The mean scores on the 4Sight (Form 4) assessment differed by less than one point, with the Control Group 1 scoring slightly higher at 30.26 (SD = 6.19) than the Treatment Group at 29.68 (SD = 6.71). These results are shown in Table 4. A look at the mean difference in scores (see Table 5) from the 4Sight (Form 2) baseline to 4Sight (Form 4) shows that the Control Group 1 actually improved almost five points while the Treatment Group 1 only improved by approximately three points. Cohen's *d* was calculated at .480 which shows that traditional instruction had a small to moderate effect on the math achievement of the students.

Another statistically significant difference was evident when looking at the score differences by gender. The females in the Control Group 1 had a mean difference of 4.91 (SD=4.16) with the females in the Treatment Group 1 showed a mean score difference of only 2.97 (SD=3.77). Cohen's *d* equaled .22 which also shows a small effect of the teachers' instruction on the females in the group. The males also differed significantly. The Control Group males had a mean difference score of 5.06 (SD=5.36) and the Treatment Group males' mean difference score was 2.83 (SD=4.239).

Table 4

Repeated Measures ANOVA of 4Sight Math Assessments in Phase One

Assessment Form	Group	N	M	SD	F	p	df n, d
4Sight Math Form 2	Control 1	39	25.28	7.16			
	Treatment 1	52	27.08	6.00			
	Total Group	91	26.31	6.55			
4Sight Math Form 4	Control 1	39	30.26	6.19	44.56	<.001	1, 38
					68.79	<.001	1, 90
	Treatment 1	52	29.98	6.71	22.22	<.001	1,51
	Total Group	91	30.10	6.46			

*p<.05

Table 5

Score Differences from 4Sight Math Assessment Form 2 to Form 4 in Phase One

Group	N	M	SD
Control 1	39	4.97	4.65
Treatment 1	52	2.90	3.94
Total Group	91	3.79	4.36

Research Question 2: How do the scores of the 4Sight Math assessment differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase one, there were seven low-achieving students in the control group and eight in the treatment group. Of the students in the control group, four were females and three were males. The treatment group consisted of seven females and one male. The low-achieving students in the control group averaged 29 minutes and 02 seconds of time logged in to Study Island as compared to the low-achieving students in the treatment group who logged an average of one hour, 34 minutes and 37 seconds. Once again, there was a wide range of times recorded from the treatment group, with some students spending as little as 25 minutes using the software and others logging more than three hours. Students' times in the control group ranged from approximately ten minutes to a little over one hour spent on Study Island. Table 3 shows the average number of sessions logged by low-achieving students in each group in phase one. The treatment group logged over three times the minutes and about two and a half times the number of sessions as the control group on Study Island.

The SPSS statistical software program was employed to conduct repeated measures ANOVA to compare the mean scores of the 4Sight Math assessment (Form 2 and Form 4) for the low-achieving students in Control Group 1 and Treatment Group 1. Table 6 shows the repeated measures ANOVA yielded a statistically insignificant result of (F (1, 14) = 3.841) with p= .070. Based on this data, the researcher failed to reject the null hypothesis related to performance of low-achieving students.

Further results (see Table 7) showed that the mean of the differences from 4Sight Math assessment Form 2 to Form 4 for the low-achieving Control Group 1 students

(N=7) was 4.57 (SD = 4.32) while the mean of the differences in the scores for the low-achieving Treatment Group 1 students (N=8) was 0.25 (SD = 3.77). One outlier score for the Treatment Group 1 had a score difference of negative seven points. Factoring out that outlier score, the treatment group had an improved average score of 1.29 points, which is still significantly less of an improvement than the low-achieving Control Group 1 students whose scores rose 4.57 points.

Table 6

Descriptive Statistics and Repeated Measures ANOVA of 4Sight Math Assessments for Low-Achieving Students in Phase One

Assessment	Group	N	M	SD	F	p	df n, d
4Sight Math (Form 2)	Control 1	7	18.71	6.26			
	Treatment 1	8	19.63	4.07			
	Total Group	15	19.20	5.03			
4Sight Math (Form 4)	Control 1	7	23.29	5.22			
					3.84	.07	1, 14
	Treatment 1	8	19.88	4.58			
	Total Group	15	21.47	5.03			

*p<.05

Table 7

Descriptive Statistics of Score Differences on 4Sight Math Assessments Form 2 to Form 4 for Low-Achieving Students in Phase One

Group	N	M	SD
Control 1	7	4.57	5.22
Treatment 1	8	0.25	3.77
Total Group	15	2.27	4.48

Research Question 3: How do the scores of the 4Sight Math assessment differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase one there were 10 high-achieving students in the control group and eighteen in the treatment group. The control group had six females and four males. In the treatment group, there were eight females and 10 males. The high-achieving students in the control group averaged 22 minutes and 51 seconds of time logged in to Study Island as compared to the high-achieving students in the treatment group who logged an average of one hour, 47 minutes and 33 seconds (see Table 2). Once again, there was a wide range of times recorded from the treatment group, with some students spending as little as 20 minutes using the software and others logging more than three hours. Students' times in the control group ranged from ten minutes to a little over 37 minutes spent on Study Island. Table 3 shows the average number of sessions logged by high-achieving students in each group in phase one. The treatment group logged over five times the minutes and about two and a half times the number of sessions as the control group on Study Island.

The SPSS statistical software program was employed to conduct repeated measures ANOVA to compare the mean scores of the 4Sight Math assessment for the high-achieving students in Control Group 1 and Treatment Group 1. Initial results from the repeated measures ANOVA displayed ($F(1, 27) = 17.63$) with $p=.0003$. Since the F value was statistically significant, the score differences between 4Sight Math assessment Form 2 and Form 4 for students in both the control and treatment groups were analyzed. As seen in Table 9, the score difference means for the Control Group 1 (N=10) was 3.00 (SD=3.53) and for the Treatment Group (N=18) was 2.11 (SD=2.83). Based on this and the data shown in Table 8, the researcher failed to reject the null hypothesis related to performance of high-achieving students.

Table 8

Descriptive Statistics and Repeated Measures ANOVA of 4Sight Math Assessments for High-Achieving Students in Phase One

Assessment	Group	N	M	SD	F	p	df n, d
4Sight Math (Form 2)	Control 1	7	33.30	2.26			
	Treatment 1	8	33.17	2.64			
	Total Group	15	33.21	2.47			
4Sight Math (Form 4)	Control 1	7	36.30	3.40			
					17.63	.0003	1, 27
	Treatment 1	8	35.28	3.18			
	Total Group	15	35.64	3.23			

*p<.05

Table 9

Descriptive Statistics for Score Differences of 4Sight Math Assessments Form 2 to Form 4 for High-Achieving Students in Phase One

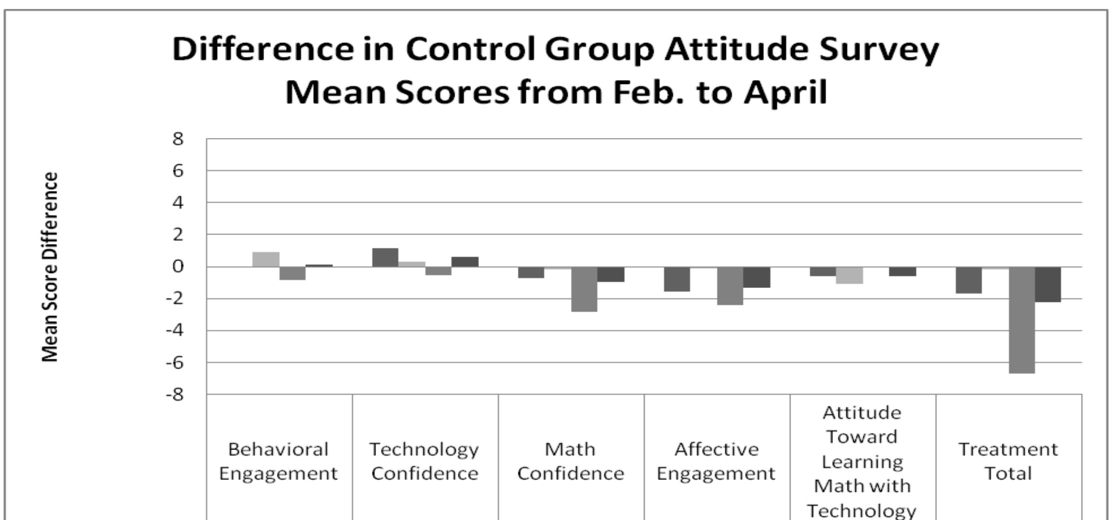
Group	N	M	SD
Control 1	7	3.00	3.53
Treatment 1	8	2.11	2.83
Total Group	15	2.43	3.06

Research Question 4: How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In the control group in phase one, there were 39 students participating: seven low-achieving students, 22 average students, and 10 high achieving students. Of these students 22 were female and 17 were male. The treatment group in phase one consisted of 52 students participating: eight low-achieving students, 26 average students, and 18 high-achieving students. In this group, there were 29 females and 23 males. The students were given the attitude survey just prior to beginning the study to provide a baseline score. This baseline score was graphed to check its shape for normality. The graph of the data (see Figure 2) is symmetrical, and the data fell into the parameters of the Empirical Rule so the data can be interpreted as approximately normal. Repeated measures ANOVA and a *t* test, therefore, were valid tests to use to compare the resulting data.

A repeated measures ANOVA was conducted on the data to determine if any difference in mean attitude survey scores can be attributed to traditional instruction or Study Island treatment. As stated earlier, this procedure factors out any error or naturally occurring variances in the population's mean scores. The repeated measures ANOVA on the attitude survey given to the whole study group in February compared to the one administered in April produced a statistically insignificant result, (F (1, 90) = 2.336, $p<.05$) and $p=.129$. This shows that a significant part of the variance in scores can be attributed to error, such as time, maturation, and test practice, with traditional instruction and use of Study Island having minimal effect. Based on this data, the researcher failed to reject the null hypothesis H_4 which stated: there will be no statistically significant difference between attitude survey scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction using IWBs.

An interesting observation when analyzing the attitude survey scores from the beginning of the study to the end of the first phase is that overall attitude scores actually fell for both the treatment and control groups (see Figures 3 and 4). In the Control Group 1, scores fell by an average of 2.21 points overall and in the Treatment Group 1 they dropped 1.75 points. While this is not statistically significant, it does show that using Study Island more often does not necessarily affect students' attitudes toward math or attitude toward the use of technology in math.



	Behavioral Engagement	Technology Confidence	Math Confidence	Affective Engagement	Attitude Toward Learning Math with Technology	Treatment Total
Average	0	1.13	-0.72	-1.54	-0.59	-1.68
High	0.9	0.3	-0.2	-0.1	-1.1	-0.2
Low	-0.85	-0.57	-2.86	-2.43	0	-6.72
Whole Group	0.1	0.62	-0.98	-1.33	-0.62	-2.21

Figure 3: Differences in Control Group Mean Scores for Attitude Survey from February to April, by Category and Achievement Level

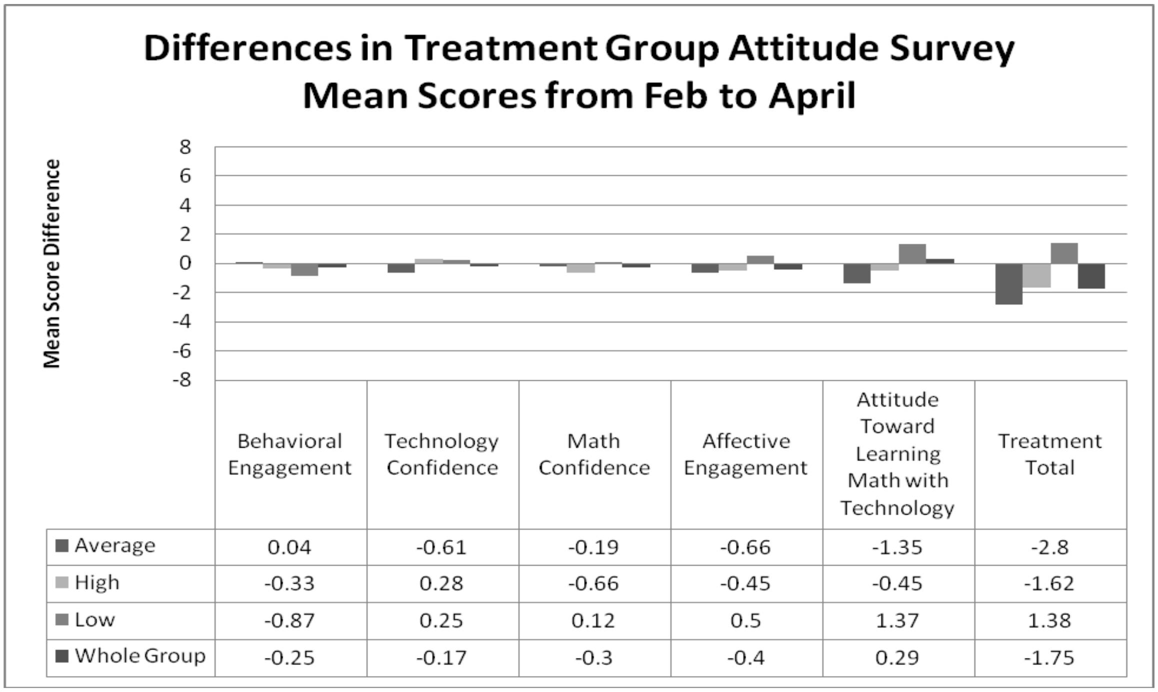


Figure 4: Differences in Treatment Group Mean Scores for Attitude Survey from February to April, by Category and Achievement Level

Table 10

Repeated Measures ANOVA for All Students in Treatment and Control Group 1 for Attitude Survey in Phase One

Group	N	Feb. M	Feb. SD	March M	March SD	F	p	df (n, d)
Control 1	39	74.77	12.11	72.56	10.18			
						2.33	.13	(1,90)
Treatment 1	52	75.85	12.32	74.10	11.39			
Whole Group	91	75.38	12.18	73.40	10.93			

*p<.05

Research Question 5: How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase one, there were seven students identified as low-achieving in the Control Group1 and eight low-achieving students in Treatment Group 1. As stated previously and shown in Table 2, the low-achieving students in the Control Group 1 spent only 29 minutes and 02 seconds on average using the Study Island software, as compared to students in Treatment Group 1 who spent an average of one hour, 34 minutes and 37 seconds using the program. This is approximately three times as many minutes as the Control Group 1 low-achieving students. In addition, the Treatment Group 1 low-achieving students participated in almost three times the number of practice sessions as their counterparts.

SPSS software was used to conduct repeated measures ANOVA for low-achieving students on the attitude survey. Analysis seen in Table 11 shows that the F value was statistically significant ($F(1, 14) = 9.737$) with p calculated at .008. As depicted in Table 12, the mean score of the differences between assessment scores for the Control Group 1 students (N=7) was 5.14 (SD= 8.03) and for the Treatment Group 1 (N=8) the mean of the difference scores was 1.38 (SD= 11.61).

The attitude survey used in this study measured five aspects of students' feelings and beliefs about math and technology. Students were asked to respond to various statements using a five-point scale ranging from Strongly Agree to Strongly Disagree.

The first category of Behavioral Engagement aimed to measure students' perceived involvement in learning with statements such as, "I really make an effort in my mathematics lessons." Technology Confidence meant to ascertain how comfortable students were using computers with statements like, "I am good at using computers." The next category of Math Confidence was to measure how strong students felt in regard to their ability to learn math. An example of a Math Confidence statement is, "I can get good results in mathematics." The category of Affective Engagement was designed to examine how students feel about learning math with a statement like, "Learning mathematics is enjoyable." The final category aimed to determine how well students liked working with computers to learn math. This category is Attitude toward Learning Mathematics with Technology and included statements such as, "Mathematics is more interesting when using computers" (Pierce, Stacey, and Barkatsas, 2005).

When further examining the scores by gender, there was a statistically significant difference between the low males in the control group and the low male in the treatment group (see Table 13). These differences arose in the category of Math Confidence, and the Total Survey. Table 13 also shows that the females mean scores in Math Confidence was statistically significant. The females in the Control Group 1 fell slightly more than two points at -2.29 (SD = 3.95), while the Treatment Group 1 females gained almost two points with 1.88 (SD=3.79). Based on the aforementioned data, the researcher rejected the null hypothesis H_5 which stated: there will be no statistically significant difference between attitude survey scores of low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction using an Interactive Whiteboard.

An analysis of the difference in mean scores for the low-achieving groups in phase one reveals some interesting facts. First, while the overall mean score for the Control Group 1 dropped by 2.21 points from February to April, the mean score for the low-achieving students in Control Group 1 fell 6.72 points (see Figure 3). This is more than three times the difference found in the whole group. Furthermore, the low-achieving students in Treatment Group 1 were the only group to show an increase in attitude scores (see Figure 4). As shown in Figure 4, the overall Treatment Group 1 average score fell by 1.75 points, but the low-achievers in this group gained 1.38 points.

Table 11

Repeated Measures ANOVA for Low-Achieving Students in Treatment and Control Group 1 Regarding Attitude Survey for Phase One

Group	N	Feb. M	Feb. SD	March M	March SD	F	p	df n, d
Control 1	7	71.43	19.61	64.71	11.63			
						9.74	.008	1, 14
Treatment 1	8	63.50	13.49	64.88	13.15			
Whole Group	15	74.20	14.89	64.8	12.02			

*p<.05

Table 12

Difference in Scores for Low Achieving Students in Treatment and Control Group 1 Regarding Attitude Survey for Phase One

Group	N	M	SD
Control 1	7	5.14	8.01
Treatment 1	8	1.38	11.61

Table 13

Independent t test for Low-Achieving Students in Treatment and Control Group 1 for Attitude Survey by Attitude Category, for Phase One

Attitude Category	Whole Group Low-Achieving Students		Low-Achieving Males (N=4)		Low-Achieving Females (N=11)	
	t (df = 13)	p	*t* (df = 2)	p	*t* (df=9)	p
Behavioral Engagement	.09	.93	-.18	.87	-.92	.38
Technology Confidence	.21	.84	-.14	.90	.66	.52
Math Confidence	1.74	.11	5.19	.04	2.20	.05
Affective Engagement	1.03	.32	-.49	.67	.08	.94
Attitude toward Learning Math with Technology	-.58	.57	2.17	.16	-.89	.39
Total Survey	.72	.48	-4.22	.05	-.16	.88
Significant value	*1.77*	*p<.05*	*2.92*	p<.05	*1.833*	p<.05

Research Question 6: How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase one, there were 10 students identified as high-achieving in the Control Group 1 and 18 high-achieving students in Treatment Group 1. As stated previously and shown in Table 2, the high-achieving students in the Control Group 1 spent only 22 minutes and 51 seconds on average using the Study Island software, as compared to students in Treatment Group 1 who spent an average of one hour, 47 minutes and 33 seconds using the program. The high-achieving students in the Treatment Group 1, therefore, spent almost four and a half times the amount of minutes using Study Island as the high-achieving students in Control Group 1. The treatment group students also completed almost three times as many sessions as those recorded by the control group students.

The repeated measures ANOVA was run to analyze the significance of the difference between the means of the two groups of students and this was conducted using the SPSS software. The F value was statistically insignificant at (F (1, 27) = .291 with p=.56. Based on this data, the researcher failed to reject the null hypothesis H_6 which stated: there will be no statistically significant difference between attitude survey scores of high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction using an Interactive Whiteboard.

When analyzing the differences in scores from February to April for the high-achieving groups, an interesting observation arose. First, while each group had a decrease in attitude score from February to April, the students in the Control Group 1 had an average drop of only .20 points as compared to the Treatment Group 1 whose scores fell 1.62 points on average (see Figures 3 and 4). This is in contrast to the low-achieving students in each group whose results showed that the low-achieving students in the Control Group 1 fell significantly more than their Treatment Group 1 counterparts.

Table 14

Repeated Measures ANOVA for High-Achieving Students in Treatment and Control Group 1 Regarding Attitude Survey for Phase One

Group	N	Feb. M	Feb. SD	March M	March SD	F	p	df (n, d)
Control 1	10	73.8	13.85	73.6	11.26			
						.291	.59	1, 27
Treatment 1	18	80.56	12.26	78.94	11.09			
Whole Group	28	78.14	13.02	77.04	11.25			

*p<.05

Results from Phase Two

Research Question 1: How do the scores of the 4Sight Math Assessment differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase two of the study, the number of participants remained 91 students. These students were designated as control or treatment based on their homeroom assignment, and were again classified as low-, average-, or high-achieving (see Table 15). The control group in phase two consisted of 52 students: eight low-achieving students, 26 average students, and 18 high-achieving students. In this group 23 were males and 29 were females. This group received traditional supplemental math instruction in this phase of the study. In the treatment group, there were 39 total students: seven low-achieving students, 22 average students, and 10 high-achieving students. This group had 17 males and 22 females. These students received computer-aided instruction using Study Island software for seven weeks. As in phase one, the control group students had access to the software since it is part of the fifth grade curriculum, but the time spent using it was very minimal (see Table 16). The teachers in the control group, in fact, did not require students use the program at all in this phase of the study. The students in the treatment group used the program for an average of approximately one hour over the seven week period. Again, as in the first phase of this study, the actual time spent on Study Island varied greatly among students in this group, with some students spending as little as 15 minutes and others spending a little over an hour and a half. Students in the control group, on the other hand, spent an average of one minute using the program, with most students not logging on to use Study Island at all. Table 17 shows the average number of sessions in which the participants were logged in to Study Island, broken down by achievement group.

Table 15

Participants in Phase Two

Group	Total Students	Low-Achieving Students	Average Students	High-Achieving Students
Control 2	52	8	26	18
Treatment 2	39	7	22	10
Total Participants	91	15	48	28

Table 16

Average Time Spent on Study Island in Phase Two

Group	Average Total Time	Low-Achieving Students Average Time	Average Students Average Time	High-Achieving Students Average Time
Control 2	0:01:48	0:03:06	0:01:57	0:01:02
Treatment 2	1:01:05	0:51:47	1:06:04	0:56:37

Note. Time shown in hh:mm:ss

Table 17

Average Number of Sessions Logged in Study Island in Phase Two

Group	Whole Group	Low-Achieving Students	Average Students	High Achieving Students
Control 2	0.40	0.75	0.46	0.17
Treatment 2	16.92	14.86	18.45	15.00

A repeated measures ANOVA was again used to determine if any difference in mean 4Sight Math assessment scores could be attributed to traditional instruction or Study Island treatment. As shown in Table 18, this analysis produced a statistically significant result, (F (1, 90)=7.351, $p<.05$). The p value was found to be .008. This shows that there is a significant difference in scores from pre-test to post-test, which was expected from both instructional methods.

Descriptive statistics was used to compare the mean of the differences in scores from the 4Sight Math assessment Form 4 to Form 5 for the Control Group 2 and the Treatment Group 2. Results depicted in Table 19 show that the mean difference score for the Control Group 2 students (N=52) was -.96 (SD=3.62) and the mean difference score for the Treatment Group 2 students (N=39) was -1.51 (SD=4.93). Based on these results, the researcher failed to reject the null hypothesis H_1 which stated: there will be no statistically significant difference between 4Sight Math assessment scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

An overview of the data in Table 18 indicates the similarities in the final mean scores of each group, as was found in phase one (see Table 4). At the beginning of this phase of the study, The Control Group 2 had an average mean score of 29.68 (SD=6.71) and the Treatment Group 2 had an average mean score of 30.26 (SD=6.19). Each group dropped in scores slightly, with the Control Group 2 falling 1.49 points to reach a final average score equaling 29.02 (SD=7.66) and the Treatment Group 2 dropping .96 points, ending with an average score of 28.77 (SD=7.91). The treatment group had two students whose scores dropped 10 or more points, and the control group had one student whose score also dropped 10 points. When these extreme scores were removed, the Control Group's drop would be .92 points and the Treatment Group's difference would be down .77 points. Again, this highlights the similarities between the two groups.

Table 18

Repeated Measures ANOVA of 4Sight Math Assessments for Phase Two

Assessment	Group	N	M	SD	F	p	df n, d
4Sight Math Form 4	Control 2	52	29.98	6.71			
	Treatment 2	39	30.26	6.19			
	Total Group	91	30.10	6.46			
4Sight Math Form 5	Control 2	52	29.02	7.66			
					7.35	.008	1,90
	Treatment 2	39	28.77	7.91			
	Total Group	91	28.91	7.73			

*p<.05

Table 19

Score Differences of 4Sight Math Assessments for Phase Two

Group	N	M	SD
Control 2	52	-.96	3.62
Treatment 2	39	-1.51	4.93
Total Group	91	1.20	4.21

Research Question 2: How do the scores of the 4Sight Math assessment (Form 4) differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase two, there were eight low-achieving students in the control group and seven in the treatment group. Of the students in the control group, seven were females and one was male. The treatment group consisted of four females and three males. The low-achieving students in the control group averaged three minutes logged in to Study Island as compared to the low-achieving students in the treatment group who logged an average of approximately 50 minutes. Once again, there was a wide range of times recorded from the treatment group, with some students spending as little as 20 minutes using the software and others logging almost an hour and a half. In the control group one student spent about 15 minutes on Study Island, with the majority of the students not logging on at all. Table 17 shows the average number of sessions logged by low-achieving students in each group in phase two. The treatment group logged seventeen times the minutes and about fifteen times the number of sessions as the control group on Study Island.

The SPSS statistical software program was employed to conduct repeated measures ANOVA to measure differences between the mean scores of the 4Sight Math assessment (Form 4 and 5) for the low-achieving students in Control Group 2 and Treatment Group 2. The F value was found to be statistically insignificant at ($F(1, 14) = .863$) and $p=.37$. Results (see Table 20) showed that the mean scores for the low-achieving Control Group 2 students ($N=8$) was 19.13 ($SD = 6.27$) while the mean scores for the low-achieving Treatment Group 2 students ($N=7$) was 21.56 ($SD = 9.24$). Based on this data (see Table 20), the researcher failed to reject the null hypothesis related to performance of low-achieving students.

An analysis of the mean difference in scores from 4Sight Math assessment (Form 4) to 4Sight Math assessment (Form 5) indicate that the Control Group 2 low-achieving students' mean scores fell an average of .75 points while the Treatment Group 2 low-achieving students' mean scores dropped by an average of 1.71 points. Each group had an outlier whose score fell more than 8 points and when this score was removed from each group, the Control Group 2 only showed a loss of .25 points as compared to the Treatment Group 2 which showed a loss of .43. Again, this illustrates how similar the groups' scores were.

Table 20

Repeated Measures ANOVA for 4Sight Math Assessments for Low-Achieving Students for Phase Two

Assessment	Group	N	M	SD	Score Difference from Form 4 to Form 5	F	p	df n, d
4Sight Math (Form 4)	Control 2	8	19.88	4.58				
	Treatment 2	7	23.29	5.22				
	Total Group	15	21.47	5.03				
4Sight Math (Form 5)	Control 2	8	19.13	6.27	-.075			
						.86	.37	1, 14
	Treatment 2	7	21.57	9.24	-1.71			
	Total Group	15	20.27	7.60	-1.20			

*p<.05

Research Question 3: How do the scores of the 4Sight Math assessment differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase two there were 18 high-achieving students in the control group and 10 in the treatment group. The control group had eight females and 10 males. In the treatment group, there were six females and four males. The high-achieving students in the control group averaged one minute logged in to Study Island as compared to the high-achieving students in the treatment group who logged an average of about an hour (see Table 16). Once again, there was a wide range of times recorded from the treatment group, with some students spending as little as 15 minutes using the software and others logging more than an hour and a half. Only one student in the control group used Study Island and the time spent was about 20 minutes. Table 17 shows the average number of sessions logged by high-achieving students in each group in phase two. The treatment group logged over fifty times the minutes and about fifteen times the number of sessions as the control group on Study Island.

The SPSS statistical software program was employed to conduct repeated measures ANOVA to determine any differences between the mean scores of the 4Sight Math assessment (Form 4 and 5) for the high-achieving students in Control Group 2 and Treatment Group 2. As seen in Table 21, a statistically insignificant F value was found ($F(1, 27) = .682$). The calculated p equals .416. Results (see Table 21) showed that the mean scores for the high-achieving Control Group 2 students (N=18) was 35.33 (SD = 2.89) while the mean scores for the high-achieving Treatment Group 2 students (N=10) was 34.90 (SD = 3.73). Based on this data shown in Table 21, the researcher failed to reject the null hypothesis related to performance of high-achieving students.

Table 21

Repeated Measures ANOVA of 4Sight Math Assessments for High-Achieving Students for Phase Two

Assessment	Group	N	M	SD	Score Diff. from Form 4 to Form 5	F	p	df n, d
4Sight Math Form 4	Control 2	18	35.28	3.18				
	Treatment 2	10	36.30	3.40				
	Total Group	28	35.64	3.23				
4Sight Math Form 5	Control 2	18	35.33	2.89	0.06			
						.68	.41	1, 27
	Treatment 2	10	34.90	3.73	-1.40			
	Total Group	28	35.18	3.15	-0.46			

*p<.05

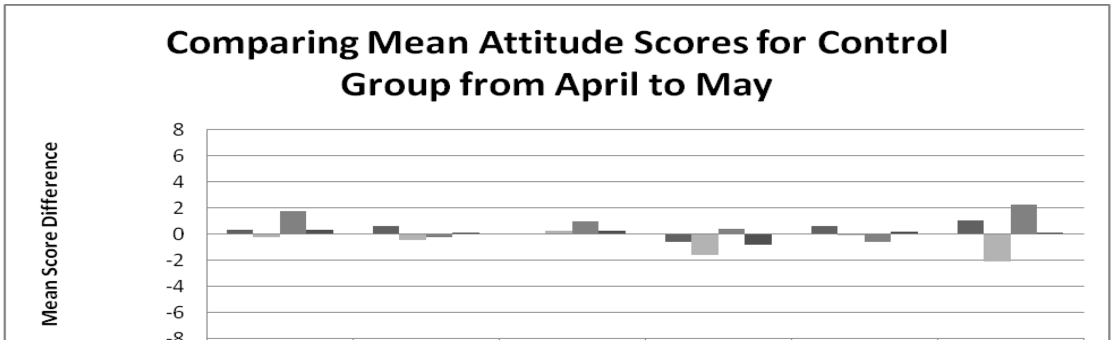
Research Question 4: How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In the control group in phase two, 52 students participated: eight low-achieving students, 26 average students, and 18 high-achieving students. In this group, there were

29 females and 23 males. The treatment group in phase two consisted of 39 students: seven low-achieving students, 22 average students, and 10 high-achieving students. Of these students 22 were female and 17 were male. The baseline score for this measure was given just prior to the teachers switching instructional methods for phase two of the study. A post-test was then given after seven weeks.

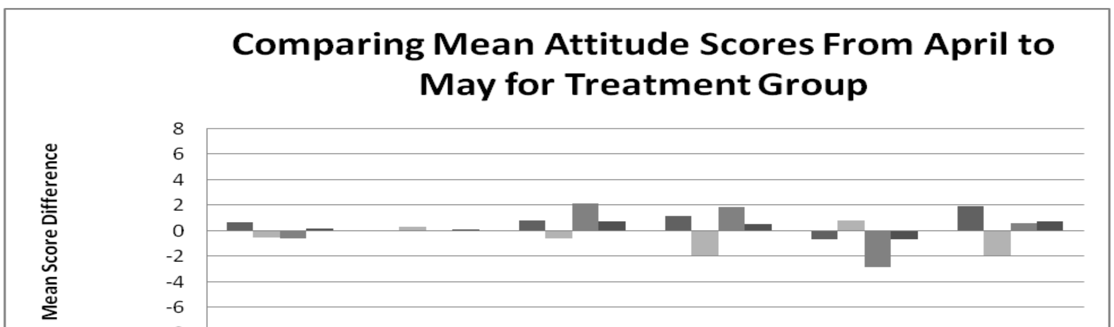
Repeated measures ANOVA was conducted on the data to determine if any difference in mean attitude survey scores can be attributed to traditional instruction or Study Island treatment. As stated earlier, this procedure factors out any error or naturally occurring variances in the population's mean scores. Shown in Table 22, the repeated measures ANOVA produced a statistically insignificant result, ($F(1,90)=.334$, $p<.05$) with $p= .565$. This shows that a significant part of the variance in scores can be attributed to error, such as time, maturation, and test practice, with traditional instruction and use of Study Island having minimal effect. Results depicted in Table 22 showed that the mean score for the Control Group 2 students (N=52) was 74.23 (SD = 11.54), while the mean score for the Treatment Group 2 students (N=39) was 73.28 (SD = 12.50). Based on this data, the researcher failed to reject the null hypothesis H_4 which stated: there will be no statistically significant difference between attitude survey scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction using an Interactive Whiteboard.

Analyzing the attitude survey scores from the beginning of this phase of the study to the end reveals how similar the groups appear to be. Overall attitude scores remained consistent, rising slightly in each group (see Figures 5 and 6). In the Control Group 2, scores rose by an average of 0.13 points overall and in the Treatment Group 2 they gained 0.72 points. It is interesting to note that each groups' attitude scores did not appear to be influenced by either form of supplemental instruction.



	Behavioral Engagement	Technology Confidence	Math Confidence	Affective Engagement	Attitude Toward Learning Math with Technology	Treatment Total
Average	0.31	0.61	0.04	-0.57	0.62	1.04
High	-0.28	-0.45	0.28	-1.61	-0.05	-2.07
Low	1.75	-0.25	1	0.37	-0.62	2.25
Whole Group	0.34	0.11	0.27	-0.79	0.19	0.13

Figure 5: Differences in Control Group Mean Scores for Attitude Survey from February to April, by Category for Phase Two



	Behavioral Engagement	Technology Confidence	Math Confidence	Affective Engagement	Attitude Toward Learning Math with Technology	Treatment Total
Average	0.68	-0.04	0.82	1.18	-0.69	1.96
High	-0.5	0.3	-0.6	-1.9	0.8	-1.9
Low	-0.58	0	2.15	1.86	-2.86	0.58
Whole Group	0.16	0.05	0.7	0.51	-0.69	0.72

Figure 6: Differences in Treatment Group Mean Scores for Attitude Survey from February to April, by Category for Phase Two

Table 22

Repeated Measures ANOVA for All Students in Treatment and Control Group 2 for Attitude Survey for Phase Two

Group	N	March M	March SD	May M	May SD	F	p	df n, d
Control 2	52	74.10	11.39	74.23	11.54			
						.334	.56	1,90
Treatment 2	39	72.56	10.18	73.28	12.50			
Whole Group	91	73.44	10.86	73.82	11.90			

*p<.05

Research Question 5: How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase two, there were eight students identified as low-achieving in the Control Group2 and seven low-achieving students in Treatment Group 2. As stated previously and shown in Table 16, most of the low-achieving students in the Control Group 2 did not spend any time using the Study Island software, as compared to students in Treatment Group 2 who spent an average of approximately 50 minutes using the program. In addition, the Treatment Group 2 low-achieving students completed almost 15 sessions on average, compared to 0.75 sessions completed on average in the Control Group 2.

Repeated measures ANOVA was run to analyze the significance of the difference between the means of the two groups of students using the SPSS software. The findings of the repeated measures ANOVA, depicted in Table 23, revealed no statistically significant differences ($F(1, 14) = .372$) with $p=.55$. Descriptive statistics also shown in Table 23 showed that the posttest mean score for the Control Group 2 students (N=8) was 67.13 (SD = 13.67), while the mean score for the Treatment Group 2 students (N=7) was 65.29 (SD = 18.79). Based on this data, the researcher failed to reject the null hypothesis H_5 which stated: there will be no statistically significant difference between attitude survey scores of low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction using an Interactive Whiteboard.

Table 23

Repeated Measures ANOVA for Low-Achieving Students in Treatment and Control Group 2 Regarding Attitude Survey for Phase Two

Group	N	March M	March SD	May M	May SD	F	p	df n, d
Control 2	8	64.88	13.15	67.13	13.67			
						.37	.55	1, 14
Treatment 2	7	64.71	11.63	65.29	18.79			
Whole Group	15	64.80	12.02	66.27	15.67			

*p<.05

An analysis of the difference in mean scores for the low-achieving groups in phase two reveals some interesting facts. First, while the overall mean score for the

Control Group 2 rose by 0.13 points from April to May, the mean score for the low-achieving students in Control Group 2 rose 2.25 points (see Figure 5). The two categories in which their scores increased the most were Behavioral Engagement and Math Confidence. This is in direct contrast with the high-achieving students in each group whose average scores dropped by approximately two points. When examining the low-achieving students in the Treatment Group 2, their overall mean scores went up by .058 points. They gained the most in Math Confidence and Affective Engagement, but went down by over two points in Attitude toward Learning Mathematics with Technology.

Research Question 6: How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?

In phase two, there were 18 students identified as high-achieving in the Control Group 2 and 10 high-achieving students in Treatment Group 2. As stated previously and shown in Table 14, only one high-achieving student in the Control Group 2 spent any time at all using the Study Island software, as compared to students in Treatment Group 2 who spent an average of about an hour using the program. The treatment group students also completed 15 sessions as compared to 0.17 sessions completed by the control group students.

Repeated measure ANOVA was employed to analyze the significance of the difference between the means of the two groups of students using the SPSS software.

The F value was found to be statistically significant at ($F(1, 27) = 4.37$) and $p=.046$ (see Table 24). Results also depicted in Table 24 show that the mean score for the Control Group 2 students ($N=18$) was 76.83 ($SD = 11.70$), while the mean score for the Treatment Group 2 students ($N=10$) was 71.70 ($SD = 13.24$). When examining the data by attitude category and gender, no significant difference was found either as evidenced in Table 25. Based on this data, the researcher failed to reject the null hypothesis H_6 which stated: there will be no statistically significant difference between attitude survey scores of high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction using an Interactive Whiteboard.

When analyzing the differences in scores from April to May for the high-achievers, many similarities were found. First, each group had a decrease in attitude score of approximately two points (see Figures 3 and 4). This is in contrast to the average and low-achieving students in each group whose results showed an increase. The category in which both groups decreased in score the most was Affective Engagement. The only observable differences between the groups were the slight rise in Technology Confidence and Attitude toward Learning Mathematics with Technology in the treatment group.

Table 24

Repeated Measures ANOVA for High Achieving Students in Treatment and Control Group 2 Regarding Attitude Survey for Phase Two

Group	N	March M	March SD	May M	May SD	F	p	df n, d
Control 2	18	78.90	11.09	76.83	11.70			
						4.37	.046	1, 27
Treatment 2	10	73.60	11.26	71.70	13.24			
Whole Group	28	77.04	11.25	75.00	12.28			

*p<.05

Table 25

Score Differences in High Achieving Students in Treatment and Control Group 2 Regarding Attitude Survey for Phase Two

Group	N	M	SD
Control 2	18	-2.11	3.95
Treatment 2	10	-1.90	7.08

Table 26

Independent t test for Students in Treatment and Control Group 2 for Attitude Survey by Attitude Category and Gender for High Achievement Level for Phase Two

Attitude Category	High-Achieving Students (N=28)		High-Achieving Females (N=14)		High-Achieving Males (N=14)	
	t (df=26)	p	*t* (df=12)	p	*t* (df=12)	p
Behavioral Engagement	.33	.74	1.68	.12	-1.38	.19
Technology Confidence	-.85	.40	-.68	.51	-.47	.65
Math Confidence	1.06	.29	1.39	.19	-.63	.54
Affective Engagement	.26	.79	1.32	.21	-.66	.52
Attitude Toward Learning Mathematics with Technology	-.48	.64	-.85	.41	.29	.78
Total Survey	-.10	.92	.59	.57	-1.09	.29
Significant value	*1.706*	*p<.05*	*1.782*	*p<.05*	*1.782*	*p<.05*

CHAPTER FIVE: DISCUSSION

Introduction

This study was conducted to determine if using technology for supplemental math instruction effected the achievement and attitude of fifth grade students. Two modes of instruction were examined: traditional instruction which included the use of IWBs and computer-aided instruction using the standards-aligned software program Study Island. Students in five fifth grade classes participated in two phases of the study: the first phase had three classes designated as the treatment group receiving the computer-aided instruction and two as the control group receiving traditional instruction using IWBs for seven weeks, and phase two had all five teachers switch modes of instruction for seven weeks.

Summary

This study took place in a small rural school district in south-central Pennsylvania. The participants were students in each of the district's five fifth grade classes. Ninety-one students participated in this quasi-experimental nonequivalent control group designed study. Intact classes were used, with teachers randomly assigned as treatment or control for the first phase of the study. In phase one, three teachers used Study Island software for approximately 20 minutes, three times per six-day cycle while two teachers provided traditional instruction using IWBs for 20 minutes three times per six-day cycle. This continued for seven weeks, and then teachers switched instructional modes for supplemental instruction for the second phase of the study. The control group, therefore, became the second treatment group and the treatment group became the second control group. The data collected were analyzed using SPSS statistical software.

Repeated measures ANOVA and, when appropriate, an independent *t*-test was conducted to determine if there was a significant difference in means on the 4Sight math assessment and the attitude survey administered as a pre- and post-test for each phase of the study.

Restatement of the Problem and Purpose

This study was ultimately intended to contribute to the body of research regarding how school districts can best improve the quality of education for all students in a technology rich society while making the best use of limited funding to support these initiatives. The specific purpose of this study was to determine if supplemental math instruction using standards-based software was more effective than traditional supplemental instruction using IWBs in improving the math achievement and attitude towards learning math for fifth grade students of varying ability levels.

Research Questions

Research Question 1

How do the scores of the 4Sight Math assessment differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard? In phase one of the study a statistically significant difference was found using repeated measures ANOVA, so the researcher rejected the null hypothesis for this phase H_1: there will be no statistically significant difference between 4Sight Math assessment scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

In phase two of the study, while the repeated measures ANOVA did reveal a significant F value, further analysis showed that there was no statistically significant difference in the mean scores, so the researcher failed to reject the null hypothesis H_1: there will be no statistically significant difference between 4Sight Math assessment scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

Research Question 2

How do the scores of the 4Sight Math assessment differ between low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard? In both phases of the study, repeated measures ANOVA produced a significant F value, but examination of the differences between the mean scores of this group showed that there was no statistically significant difference. For this reason, the researcher failed to reject the null hypothesis H_2: there will be no statistically significant difference between 4Sight Math assessment scores of low-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

Research Question 3

How do the scores of the 4Sight Math assessment differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based *software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard?* Repeated measures ANOVA showed no statistically significant differences between the control and treatment group in either phase of the study, so the researcher failed to reject the null hypothesis H_3: there will be no statistically significant difference between 4Sight Math assessment scores of high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

Research Question 4

How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard? When examining the results of the repeated measures ANOVA for the whole group in both phases of the study, no statistically significant difference was found, leading the researcher to fail to reject the null hypothesis H_4: there will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade students receiving computer-aided instruction using a standards-based software program and fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard.

Research Question 5

How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between low achieving fifth grade students receiving computer-aided instruction using a standards-based software program and low achieving fifth grade *students receiving traditional instruction utilizing an Interactive Whiteboard?* The results of the repeated measures ANOVA gave a statistically significant F value for the low-achieving students in phase one. Significant differences were found when examining the scores by gender. This led the researcher to reject the null hypothesis H_5: there will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade low-achieving students receiving computer-aided instruction using a standards-based software program and fifth grade low-achieving students receiving traditional instruction utilizing an Interactive Whiteboard.

In the second phase of the study, however, no statistically significant differences were found between the group on repeated measures ANOVA, so this led the researcher to ultimately fail to reject the null hypothesis $H_{5:}$ there will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade low-achieving students receiving computer-aided instruction using a standards-based software program and fifth grade low-achieving students receiving traditional instruction utilizing an Interactive Whiteboard.

Research Question 6

How do attitudinal scores on the Mathematics and Technology Attitude Scale (MTAS) differ between high-achieving fifth grade students receiving computer-aided instruction using a standards-based software program and high-achieving fifth grade students receiving traditional instruction utilizing an Interactive Whiteboard? When the repeated measure ANOVA was employed in each phase of the study to determine a significant difference between the means treatment and control groups' high-achieving students, the F value was not statistically significant. For this reason, the researcher failed to reject the null hypothesis H_6: there will be no statistically significant difference between Mathematics and Technology Attitude Scale scores of fifth grade high-achieving students receiving computer-aided instruction using a standards-based software program and fifth grade high-achieving students receiving traditional instruction utilizing an Interactive Whiteboard.

Discussion of Results

Research Question 1

The results of this study revealed that using supplemental computer-aided math instruction had small to moderate effect on the achievement of the fifth grade participants in the first phase, but no significant effect in the second phase. In phase one of the study, the Control Group 1 had an increase of almost five points in math achievement as measured by the 4Sight Math assessment while the Treatment Group 1 had an increase of only three points. This is a significant amount of growth for this assessment over a seven-week time period. The greater effect of traditional instruction in this phase of the study is the opposite of the findings of Christmann and Badgett (2003) who found a small effect on student achievement due to the technology implementation after analyzing 39 studies which examined the effect of computer-aided instruction compared to traditional teaching. It also reflects the findings of Cheung and Slavin (2012) whose meta-analysis of technology applications and their effects on reading achievement only minimally impacted student learning since the computer-aided instruction group did make gains in achievement, just not as large as those receiving traditional instruction. Davis (2012) and Tienken and Maker (2008) also found no significant impact on student achievement after using technology.

This study's results, however, are in direct contrast to Cheung and Slavin's (2011) meta-analysis of the effect of technology on math achievement of K-12 students. Their study found that technology used as a supplement to traditional math instruction had the strongest impact on students' learning. One possible explanation of this discrepancy is the quality of software being used for the supplemental instruction. Wayang Outpost (Aleven, et al., 2011) and FCAT Explorer (Martindale, et al., 2005) are programs whose effectiveness has been shown to have a positive effect on student achievement in math. Study Island software was reported to have the components that linked math achievement to its use: practice in math fluency and problem solving, flexibility in practice level to meet the needs of all students, and connections between known information and new information (Hadjerrouit, 2011; Sinclair & Crespo, 2006). Empirical research regarding Study Island software, however, is very limited and for this population is obviously not as effective in increasing mathematics achievement as technology was shown to be in the previously mentioned studies (Cheung & Slavin, 2011; Aleven, et al., 2011; Martindale, et al., 2005; Hadjerrouit, 2011; Sinclair & Crespo, 2006).

One other factor which may have resulted in a lower rate of growth in achievement in the students in the treatment group was the amount of time actually spent using the software. Wilkekumar et al. (2009) examined the software program Odyssey Math for its effectiveness in helping fourth grade students achieve in math but found no significant difference at the end of the school year. The authors recommended using the program for 60 minutes each week, but actual usage was closer to 38 minutes per week on average (Wilkekumar, et al., 2009). This researcher recommended using Study Island software for 60 minutes per six-day cycle for an average of six hours per seven week period, but actual usage for phase one was approximately one and a half hours and in phase two was only a little over one hour. The limited usage may have been the reason that students did not excel as expected. That being said, both the control and treatment groups started the study with average mean scores in the Basic range and after the first phase of the study both groups reached an average mean score that showed Proficiency.

The results of phase two of this study showed that each group scored within one point of each other. Each group also had mean scores that actually fell by a little over a point on average from their baseline test score at the end of March. While this may seem surprising since the teachers in the study continued to have regular math instruction for 60 minutes each day, as well as provide additional instruction three times every six days, this is not a new phenomenon for fifth graders at the end of the school year. Experienced teachers will collectively attest to the increased difficulty of keeping students focused on learning during the last month of school, especially when the important state mandated testing is over. Teachers relax the pressure on students to excel since all math standards are expected to be mastered by the time the state testing occurs, which in Pennsylvania is in early April. Students at this age realize that end of the year local assessments, like the 4Sight Math assessment, do not impact their report card grades and while the assessment results are reported to parents, there are no assumed consequences for performing poorly.

In addition, the results seem to indicate that the approach with the greatest impact on achievement was traditional instruction coupled with minimal use of Study Island. The group with the greatest improvement in achievement was the Control Group 1 which was the only group to use this combination of math practice. The approach which got the next best outcome was traditional instruction. Control Group 2 only had a few students on Study Island at all and while their 4Sight math scores went down, it was less of a drop than the Treatment 2 group, showing that the teacher-led instruction had better results than the computer-aided instruction.

Research Question 2

The study showed no statistically significant difference between the low-achieving students in the control group and the treatment group for either phase. These results match the study conducted by Hunter (2012) in which computer-aided instruction was employed to help struggling math students, but no statistically significant differences were found. Like the overall groups' mean scores, scores of the low-achieving students in the Control Group 1 rose five points on the post-test compared to the scores of the low-achieving students in the Treatment Group 1 scores which only went up one quarter of a point. Even when factoring out an outlier score in the Treatment Group 1 which fell seven points, the improvement of this group was only 1.29 points which is still much less of a gain than their Control Group 1 counterparts. In practical terms, low-achieving students in the Control Group 1 went from an average mean score in the Below Basic range to the Basic level. In contrast, the low-achieving students in the Treatment Group 1 stayed in the Below Basic level. In phase two of the study, results dropped the students in the Treatment Group 2 from the Basic level to Below Basic, while the Control Group 2 students remained in the lowest possible range of scores (i.e. Below Basic).

The findings of this study refute many current research studies regarding low-achieving students. In a meta-analysis of studies conducted over the last two decades, Qing and Xin (2010), for example, found moderately high positive effects of using computer technology on student achievement in math, especially for special education students. Similarly, positive effects on reading achievement were found with at-risk elementary students (Saine, et al., 2011; Volpe, et al., 2011; Chambers, et al., 2011). Some possible explanations for this difference may lie in the software Study Island. The software is not intuitive in that it does not automatically place students on an appropriate practice level based on the pre-test. While the program does put students in additional practice sessions when they do not meet the Proficient level, teachers must manually place students on a lower level and adjust difficulty to accommodate for specific learning needs. While the teachers in this study were instructed in how to accommodate for individual students needs before beginning the treatment, most decisions to place students on lower-level practice were based on general observations of the students' abilities rather than on specific analysis of his/her performance using the software. This is evidenced by the number of students whose average scores were in the Below Basic range during their practice sessions on Study Island. For example, in the Treatment Group 1, more than half of the students had average scores in the Below Basic range with only one of these students placed in a lower grade level for his sessions. Similarly, in the Treatment Group 2, four of the students had overall practice scores that fell in the Basic or Below Basic range and were not placed on lower grade level material.

In addition, Reimer and Moyer (2005) found that immediate feedback was very beneficial in helping students to increase their understanding of a math concept. Study Island does not offer this type of support automatically. For example, the software does not offer an explanation of wrong answers or give review strategies at the time the student is working on the problem. This is not available until the student has completed the entire set of problems. Also, the student can simply click each choice until they get the answer and the program will continue to give them more problems. At the end of a session, the student is given the opportunity to go back over problems missed. If they choose to do so, the program simply gives them the same problems again and once more the student can click answers until he finds the correct one. There is another button the students can click which offers an explanation, but the explanation requires that the students read a sentence or two and often low-achievers, especially those who are struggling readers, will not choose to do this. Teachers, on the other hand, do provide immediate and specific feedback when a student gives an answer in class or on papers that are completed. This appears to be more effective in helping low-achieving students to learn since the students in Control Group 1 increased their scores much more than the low-achievers in Treatment Group 1, and Control Group 2 had less of a drop in scores than Treatment Group 2 students.

Research Question 3

When examining the 4Sight Math assessment scores of the high-achieving students, there was no statistically significant difference between the treatment and control groups. There is very little research specifically targeting the students who meet or exceed grade level expectation and the effects of computer-aided instruction on their achievement, although studies have shown that all students of this generation view technology as an essential part of their lives and appreciate the options it gives them for learning (Gorra, et al, 2010).

In the first phase of this study, the Control Group 1 high-achievers had an average mean score that rose three points while their Treatment Group 1 gained two points. This again shows that using Study Island did not have more of an effect on student achievement than traditional instruction. In fact, when looking at the results from phase two, the Control Group 2 scores remained constant, rising slightly, while the Treatment Group 2 scores dropped over a point. This again would indicate that a teacher's instruction has more of an impact on student achievement than computer-aided instruction.

Part of the reason for the lack of impact of using technology may again be attributed to the software Study Island and how it was used. Even though each teacher had students who fell into the high-achiever range, no students were placed in a higher grade level for practice sessions. Seven out of the 18 students in the Treatment Group 1 and seven out of the ten students in the Treatment Group 2 scored Advanced overall for their practice sessions, so they possibly were not adequately challenged by the material. Another possible reason for the lack of difference is that these students had already reached the Proficient level and did not have any reason to strive for the Advanced score. The time spent using the software may be another factor impacting achievement. The students in Treatment Group 1 used the program for 30 minutes more on average and had scores that increased by over two points. In contrast, the Treatment Group 2 used the program less and their scores fell by almost one and a half points.

Research Question 4

The results of the attitude survey did not show any statistically significant differences between the control and treatment groups in either phase of the study. This does not correlate with the findings of the literature review, although research in this area is limited. Available research showed that students who used computers for school work had increases in attitude toward learning math, motivation to learn, and active involvement in their learning (Petscher, 2010; House &Telese, 2011; Furner & Marinas, 2007; Dresel & Haugwitz, 2008). One possible explanation for this is that the students in the study had relatively high scores in each area of the survey to begin. Students in both groups had mean scores that ranged from 13.23 to 16.46 which align with the moderately high range on the attitude scale, indicating a positive attitude. Scores of 12 and below are considered low while scores 17 and above are high. A second possible reason for the lack of increase in attitude is that most of the students have been using this software since kindergarten. The novelty effect is obviously not a factor and in fact students may simply not find the program enjoyable to use.

When looking at each category of the attitude survey given at the end of phase one of the study, the students in the treatment group scored higher than the control group students in every part except Behavioral Engagement, but all mean scores were within one point of each other. This implies that students' attitudes were not impacted by using computers more than traditional instruction. The only significant difference found was in Attitude toward Learning Mathematics with Technology when the groups were broken down by gender. Gurian and Stevens (2004) present evidence of gender differences in learning preferences, and both software programs and IWBs can appeal to the learning needs of females and males. The females in the treatment group seemingly enjoyed using the computer for math practice better than their counterparts in the control liked receiving traditional instruction.

Results in phase two also show little overall differences. When breaking the survey down by category, the students in Treatment Group 2 had scores that increased by an average of one half a point while the students in Control Group 2 dropped almost a point. In contrast, the Treatment Group 2 fell by almost a point in Attitude toward Learning Mathematics with Technology while the Control Group 2 students had a slight rise in their average score. This may correspond with the research of Sunha and Mido (2010) who found that students who used the computer "Sometimes" responded more positively than students who used it "Daily" or "Never".

A look at the results by gender does reveal some statistically significant differences between the Treatment Group 2 and Control Group 2. Males in the treatment group scored significantly higher in the categories of Behavioral Engagement, Affective Engagement, and in the total survey score. This is possibly due to the idea that the computer usage appealed to their learning preferences since it allows for more interaction and movement than traditional instruction (Gurian & Stevens, 2004). Another difference discovered in this phase was between the females. Females in the Control Group 2 actually had significantly higher scores in Attitude toward Learning Mathematics with Technology as well as in the total survey score. While this may seem surprising, it actually shows how consistent their attitudes remained from phase one to phase two. This group was the Treatment Group 1 in phase one whose scores were also significantly different (higher) in Attitude toward Learning Mathematics with Technology. The consistent scores show again that the use of computers probably had little effect on their attitudes toward math and technology.

Research Question 5

The overall results of the low-achieving students in both phases of this study did not have any statistically significant results. As stated previously, this contrasts the current available research regarding low-achieving students and the effect technology has on their attitude toward learning. Also stated previously, a possible explanation for this is the software program that was used and the limited time that students spent using the computer. For low-achieving students, specific feedback helps to motivate them to continue to work as long as the task is within their zone of proximal development (Powell & Kalina, 2009; Dresel & Haugwitz, 2008). Study Island does not provide this easily. The program flashes a star if the student gets the answer right, and a red check mark if the answer is wrong. It does not, however, give the student any indication as to why the answer is wrong or how to think through the problem until the student has completed the whole set of problems. This lack of specific feedback may contribute to the lack of motivation growth in the treatment group students.

While not statistically significant, an educator would find the discrepancy between the Control Group 1 and Treatment Group 1 mean scores important. The students in the Treatment Group 1 had mean scores that improved by a little more than one point, thus indicating that using computers did not significantly impact their attitude toward math or computers. They did, however, move from three scores in the Low range and two in the Moderately High range to having two scores in the Low range and three in the Moderately High range. On the other hand, the students in the Control Group 1 had mean scores that dropped almost seven points from the beginning of the study to the end of the first phase seven weeks later. This group initially had all attitude scores in the Moderately High range, with the exception of one category (Technology Confidence) which fell in the Low range. At the end of the first phase of the study, however, they only had two categories in which they scored Moderately High and three in which they scored in the Low range. This is noteworthy since a drop in attitude score can indicate a decrease in motivation which can also translate into poor performance. Since the low-achievers in the treatment group were the only group to have an increase in attitude scores, one could possibly conclude that using computers for math practice appeals to struggling learners more than traditional instruction despite the fact that it does not positively impact their achievement.

The results of the attitude survey, although statistically significant in phase one when broken down by gender, need to be taken with extreme caution since the sample was so small. There was only one male student in the Treatment Group 1 and only three male students in the Control Group 1 so findings can be generalized on a very limited basis. The male students in the control group did have significantly higher scores in Math Confidence and in the Total Survey score. The only conclusion one can draw from this, however, is that the student in the treatment group did not have nearly the positive outlook in math and technology as his peers. All of his scores, in fact, fell in the Low range on the attitude scale with the exception of Technology Confidence which was in the Moderately High range. When checking phase two findings, this student, now in the Control Group 2, continued to have low scores, especially in Math Confidence and Affective Engagement which were significantly lower than the Treatment Group 2 scores. Neither instructional mode had a significant effect on his attitude.

The females in the first phase also had scores that differed significantly in one category of the attitude survey, Math Confidence. The students in the Control Group 1 dropped approximately four points and the Treatment Group 1 gained a fraction of a point. This would seem to indicate that the females in the low-achieving group responded with more confidence to the computer-aided instruction, since their attitude scores in Math Confidence went up during phase two of the study when they were the Treatment Group.

Phase two results for all low-achievers indicate small differences between groups. The low-achieving students in the control group actually did have scores increase by an average of 2.25 points while the scores in the treatment group only rose about a half point on average. The treatment group showed a notable increase in Math Confidence and Affective Engagement, indicating that the computer use had a small effect on their perceived ability and enjoyment of math. On the other hand, the control group had small increases in Behavioral Engagement, Math Confidence, and Affective Engagement for a stronger final score, indicating that traditional instruction made them feel more capable and involved in their learning.

Research Question 6

Even though there were no statistically significant differences in the high-achieving group in either phase of the study, there were some interesting observations that could be made from the data collected. The students in Treatment Group 1 scored higher than the students in the Control Group 1 in two categories of the attitude survey. These categories were Technology Confidence and Attitude toward Learning Mathematics with Technology. While there is very limited research regarding high-achieving students and attitude with computer-aided instruction, these results do match the available research which, as previously stated, showed that computers utilized for school work was linked to increases in students' attitude toward learning math, motivation to learn, and active involvement in their learning (Petscher, 2010; House &Telese, 2011; Furner & Marinas, 2007; Dresel & Haugwitz, 2008).

These results would indicate that the higher-achieving students found working on the computer made them more confident and that they preferred practicing math using the software better than the students who were in the traditional instruction group. It is curious to note, however, that the high-achieving students' scores actually dropped a little over a point and a half from the beginning of the study, with the biggest drop in Math Confidence. Perhaps their initial thoughts about their ability to do math changed as the curriculum became more challenging. This ironically is one of the categories in which their scores were the most different from the control group. The control group, in contrast, stayed relatively the same in each category except for Attitude toward Learning Math with Technology which fell about a point on average.

Another interesting fact is that the students in the high-achieving Treatment Group 1 consistently scored in upper range of the Moderately High scores from beginning to end, while the high-achieving students in Control Group 1 consistently scored Moderately High in each category except Behavioral Engagement which climbed into the High range on the post-test and the Attitude toward Learning Mathematics with Technology which was in the Low range on both the pre- and post-survey.

In the second phase of the study, there was a five point difference in the final total attitude survey score between the two groups, but the overall score differences were not statistically significant. An overview of the score differences also reveals the similarities of each groups' scores from the beginning of this phase of the study to the end.

Implications

There is a tremendous push for schools to implement technology in the classroom. Many schools are pushing for a 1:1 ratio of laptop to student. The district, in which this study was conducted, in fact, is strongly considering purchasing Chromebooks for each student in seventh through twelfth grade. In addition, there is a multitude of software and Internet-based options for schools to purchase in an effort to help students succeed in this technology-rich society. This underscores the importance for sound empirical research to help schools make these decisions. To help accomplish this, three specific topics should be examined further.

Software

The district in this study has been using Study Island software for approximately 10 years. The company has made some upgrades to the program over the years, but the results of this study seem to imply that it does not have a strong impact on student attitude and achievement in math, so it may be worthwhile for the district to explore other software options. Quality software should meet the following requirements: (a) allow teachers to differentiate practice to accommodate the learning needs of all students (Broderick, et al., 2005; Hadjerrrouit, 2011), (b) provide continuous motion which emphasizes the content, (c) demonstrate connections between math topics (Sinclair & Crespo, 2006), and (d) provide immediate and specific feedback (Dresel & Haugwitz, 2008).

Time

Since the software was not used as frequently as this researcher recommended, this may have contributed to the lack of impact. There was not, however, enough evidence gathered in this study to determine if this would indeed impact student achievement and would significantly cut into instructional time. One of the challenges facing teachers is a very crowded curriculum, and to make adding more time even more difficult there are scheduling issues associated with using the computer lab. Teachers have a limited number of instructional minutes during the day in which to teach all required content, and oftentimes the teacher feels that direct instruction is more time efficient than using the computer. Part of the reason for this is that when all the students in one class access the computer system to use the program, it can sometimes take three or more minutes for the computers to start up and open the program, which multiplied by the number of times the students try to use the software can consume a significant amount of instructional time. In one nine-week period, for example, if the students access the program 18 times and it takes three minutes to log in, that would equal almost an hour of instructional time. Chromebooks, on the other hand, could eliminate this problem since they only take approximately eight seconds to start up and run. Also, it is sometimes difficult to have access to the computer lab or computer cart since all of the students in the school share these resources, but this is an issue that could be addressed by a 1:1 initiative.

Professional Development

Regardless of what program is being utilized, professional development is crucial. Simply providing access to computers or software does not ensure success for students. Studies have shown that adequate teacher training and consequent support are keys to successful implementation (Cavanaugh, et al., 2011; Ozel, et al., 2008). In this study, for example, the researcher provided instruction in how to differentiate practice sessions for students, but no follow-up support was provided. Consequently, some students were placed on a level that did not provide sufficient challenge, while others were practicing material with little success. Neither of these situations helped the student to grow in his knowledge of the content or increase his feelings of competence in the subject. Appropriate placement and closer monitoring of student progress could have changed the success of the students and impacted their attitude as well.

Assumptions and Limitations

Assumptions

This researcher made a few assumptions in regard to this study. First, the researcher assumed that the demographic data regarding the school district were accurate as described by the school personnel. The researcher also assumed that the teachers followed the lesson plans that were submitted for the supplemental math lessons for both Study Island and traditional instruction. Observations confirmed that there were times when other events precluded the use of Study Island and supplemental traditional instruction. Since the teachers collaborate within buildings, these omissions were consistent from treatment to control group so the researcher assumed the overall instructional times remained equal. It was also assumed that the 4Sight Math assessment was valid and reliable (information retrieved from PaTTAN.net, August, 2010; 4Sight Correlation Updates, 2008; 4Sight Reading and Math Benchmarks, 2008; Castagna ,2008). Finally, it was assumed that the MTAS was a reliable and valid instrument for measuring student attitude (Pierce, et al., 2007).

Limitations

This study had several limitations. First, the sample size was of concern. The 91 participants exceeded the requirements of at least 15 students in each group, but the subgroups did not meet this number. Ideally, the study would have contained 15 students in each of the low-achieving groups instead of the seven and eight students that comprised the treatment and control groups. The number of students in the high-achieving group was also a little small at 10 participants in one of the groups. The baseline testing, however, revealed a normal distribution of scores for each measure so repeated measures ANOVA and an independent samples *t* test were still appropriate statistics to run on the collected data.

A second limitation for this study was the population from which the students were chosen. The public school in which these students attended fifth grade is located in a rural part of south-central Pennsylvania whose population is 95% Caucasian. Approximately 40% of the students qualify for free or reduced lunch as dictated by federal guidelines. These demographics may reduce generalizations of results to other populations of students with different ethnic backgrounds or socio-economic status. Along with this limitation, there may have been a selection bias inherent in the study. Students in this district are not placed in classrooms on a random basis. Instead, there is a concerted team effort to equalize classes on the basis of gender, student achievement level, and other special needs.

Another factor which is difficult to control is teacher influence. The researcher randomly assigned teachers to treatment or control and conducted the study in two phases to mitigate some of this bias. Each teacher spent one seven-week period as control using traditional instruction and one seven-week period incorporating computer-aided instruction for treatment. This counterbalancing attempted to equalize teacher impact for both groups.

Maturation of participants is also a potential factor in the study's results. Physical and emotional changes from the beginning to the end of the study may have affected the students' responses to the study measures. Test practice is another variable that may have affected the study's results since the same tests were used three times during the study.

The final two limitations are the two with potentially the strongest influence. First, the attitude measure required students to make honest responses about their confidence and perceived ability in math and while using technology. There is always an inherent possibility that students will simply circle random numbers for each question regardless of their true feelings or assessment of their abilities. These random responses would obviously compromise the findings.

Finally, the fidelity of implementation is another concern. Random observations were conducted to endure that teachers were indeed following the lesson plans that they had submitted for both instructional modes. On several occasions when the researcher went to observe, the teacher was engaged in another activity or lesson with the students instead of supplemental math instruction. This is clear in the time students spent using Study Island. Instead of the recommended six hours, each treatment group spent only one to one and a half hours using the program. This is a natural result of a very crowded curriculum with teachers trying to cover each required standard for each subject. It is assumed, however, that teachers upheld the requirements of the study as stringently as possible on days that the researcher was not there to observe. Another reason for the limited time devoted to supplemental math instruction was the time of year for the second phase of the study. The first phase took place during the critical time period before the

PSSA test was given, the required state assessment for Pennsylvania, so teachers felt pressure to cover all the required math standards. After the test, however, the standards had been covered and there was no more external pressure to conduct “extra” math lessons. In addition, as fifth graders, this was their last year in elementary school so the end of the year included several special celebrations and ceremonies which also detracted from instruction. Based on interviews with the teachers, however, it was determined that the supplemental instructional time for both control and treatment groups did remain equal for both phases of the study.

Recommendations from the Limitations

To substantiate this study’s results, the study should be conducted at a school with similar demographics to see if the results are consistent. If possible, a larger sample should be used to better meet the recommendations for a strong study. The time of year that the study is conducted should be considered, as well. The second and third nine weeks of schools would be a more ideal time frame because this would allow students to smoothly transition and feel comfortable in the new grade, while avoiding the “end-of-year” slump that can occur. This time frame may also allow for a more consistent schedule which would help teachers to use the program as prescribed.

To further validate the study’s findings, a researcher should choose a different population to replicate the study and see if the results remain the same. Using computer-aided instruction in other subjects would also be worth studying.

Recommendations for Further Research

The use of the computer-aided instruction did not have a strong impact on the achievement of the participants in this study, although it did positively influence the attitude of low-achieving students in the first phase, with a little less of a positive impact for the low-achieving students in phase two. These results suggest that further research is needed.

To begin, the study should be replicated with varying time allotted to supplemental instruction using the software. It would be valuable to determine if more or less time spent using the program had a larger impact on student achievement or attitude, especially when considering the subgroups of low- and high-achievers. This would build upon this study and a similar study using Odyssey Math which examined the effectiveness of the program in helping to increase math achievement (Wijekumar, et al., 2009). In the aforementioned study, students used the Odyssey Math software for 38 minutes per week instead of the recommended 60 minutes with no notable differences in student math achievement detected. Extending the study beyond seven weeks could also produce more significant results.

A study incorporating a different software program or another web-based resource would be beneficial as well. Study Island has been used in the district for many years and the fact that students in the study have used the same program for six years could certainly reduce the impact it may have on achievement and attitude. After this period of time, even when increasing the time spent using it and altering the conditions in which the students practice, students may simply be tired of it and fail to respond to the positive graphics and enticement of earning “blue ribbons” for proficient performances. Conducting the study with a population of similar demographics but a different software program could well produce significant differences in student attitude and achievement.

A final recommendation for further study is to use a qualitative approach in examining student attitude toward learning with technology. Very little research has been conducted in this area, especially when considering high-achieving students. An alternative form of assessing student attitude would possibly reveal more information about why students feel the way they report. Instead of having students respond on a rating scale to statements like "I am good at math," a researcher could interview each student and have each expound upon what makes him/her think he/she is good at math. Written responses instead of circling strength of response on a questionnaire to statements such as this could also provide more information about why the students responded the way they did. This information could prove very valuable to teachers trying to motivate all students.

Conclusion

There is a strong push for the integration of technology into education from many fronts. Many schools are committed to providing Tablets, Chromebooks, Palm Pilots, laptops, and other similar equipment to every student. Research, however, showing the effectiveness of this technology is inconsistent. Many studies show that today's students perform better and are more highly motivated when using a variety of technological tools (Ransdell, et al., 2011; Twenge, 2009; Fengfeng, 2008; Gillespie, et al., 2010; Gorra, et al., 2010; Frye & Dornish, 2008). There are also studies refuting these positive aspects of technology, revealing little or no effect on students' achievement (Larkin & Finger, 2011; Digregorio & Sobel-Lojeski, 2010; Campbell, 2010). This indicates that further research needs to be conducted to help school districts make informed decisions that could positively impact the academic achievement and attitude of its students.

This study found little statistically significant differences between students who received supplemental instruction using IWBs and students who received computer-aided instruction for supplemental practice. The study revealed that, especially in the first phase, teachers had a stronger positive impact on student achievement than the computer program. Nothing can replace explicit planning and moment-to-moment feedback provided by teachers when trying to help students learn and practice new content. This is not to say that technology should be discounted. As shown by the strong positive growth in the Control Group 1 math assessment scores, it could possibly be a balanced combination of teacher-led instruction and computer-aided practice that is the most effective in meeting the needs of all students.

The one area in which this study did have significant results was in regard to low-achieving students' confidence in learning math. The low-achieving students seemed to have the strongest positive reaction to using the technology, especially when considering the male learner. The message to teachers may be that low-achievers need a little more practice at their own level and that can be easily supplied by a computer program. This arena allows students to progress at their own pace instead of being influenced by the group of students who may be ready to move to a different activity. Additional research needs to clarify how and why these students respond to this type of instruction and offer teachers explicit ways to help these students to continue to achieve. A teacher's enthusiasm and passion for the content to be learned is contagious and can spark the same emotions in all students regardless of the mode of instruction.

Technology is part of today's schools and today's society. Teachers need to be informed with sound empirical research as to how to best employ the tools they are given to efficiently meet the diverse needs of this generation of learners. School districts need to be informed with sound empirical research regarding best practices, how to educate its teachers, and how to provide them with the resources needed to help every student succeed to his highest potential. This study demonstrated the positive influence of enthusiastic teachers on the attitude and achievement of fifth grade math students using a combined approach of using traditional teaching methods and technology. It has shown that this hybrid approach to learning just may be the approach districts need to best prepare their students for the future.

REFERENCES

Aleven, V., Kay, J., Arroyo, I., Royer, J. M., & Woolf, B. P. (2011). Using an intelligent tutor and math fluency training to improve math performance. *International Journal of Artificial Intelligence in Education*, *21*(1/2), 135-152.

Alloway, T., Banner, G. E., & Smith, P. (2010). Working memory and cognitive styles in adolescents' attainment. *British Journal Of Educational Psychology, 80*(4), 567-581. doi:10.1348/000709910X494566

Anghileri, J. (2006). Scaffolding practices that enhance mathematics learning. *Journal of Mathematics Teacher Education, 9*(1), 33-52. doi:10.1007/s10857-006-9005-9

Becker, J. D. (2008). The digital horserace: An analysis of differences in student computer use across the states and across the years. *Journal Of Educational Computing Research, 39*(3), 285-312. doi:10.2190/EC.39.3.e

Blue, E., & Tirotta, R. (2011). The benefits & drawbacks of integrating cloud computing and interactive whiteboards in teacher preparation. *Techtrends: Linking Research & Practice to Improve Learning, 55*(3), 31-39. doi:10.1007/s11528-011-0495-7

Broderick, A., Mehta-Parekh, H., & Reid, D. K. (2005). Differentiating instruction for disabled students in inclusive classrooms. *Theory into Practice, 44*(3), 194-202. doi:10.1207/s15430421tip4403_3

Campbell, T. (2010, January 1). *The effects of white boards on student achievement in fourth grade mathematics as measures on the Palmetto Achievement Test (PACT) at selected schools in north central South Carolina.*

Castagna, D. R. (2008). *A quantitative case study analysis of the 4Sight benchmark assessment* (Unpublished doctoral dissertation). University of Pittsburgh, Pittsburgh, Pennsylvania. Retrieved from http://etd.library.pitt.edu/ETD/-available/etd-11172008-133215/

Cavanaugh, C., Dawson, K., & Ritzhaupt, A. (2011). An evaluation of the conditions, processes, and consequences of laptop computing in K-12 classrooms. *Journal of Educational Computing Research, 45*(3), 359-378.

Chambers, B., Slavin, R., Madden, N. A., Abrami, P., Logan, M. K., & Gifford, R. (2011). Small-group, computer-assisted tutoring to improve reading outcomes for struggling first and second graders. *Elementary School Journal, 111*(4), 625-640.

Cheung, A. K., & Slavin, R. E. (2012). How features of educational technology applications affect student reading outcomes: A meta-analysis. *Educational Research Review, 7*(3), 198-215. doi:10.1016/j.edurev.2012.05.002

Cheung, A. K., Slavin, R. E., & Center for Data-Driven Reform in Education. (2011). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. *Best Evidence Encyclopedia* (BEE). Center for Research and Reform in Education.

Christensen, Clayton M., Michael B. Horn, and Curtis W. Johnson. *Disrupting class: how disruptive innovation will change the way the world learns*. New York: McGraw-Hill, 2008. Print.

Christmann, E. P., & Badgett, J. L. (2003). A meta-analytic comparison of the effects of computer-assisted instruction on elementary students' academic achievement. *Information Technology in Childhood Education Annual, 2003*(1), 91-104.

Cole, J. E., & Wasburn-Moses, L. H. (2010). Going beyond "The Math Wars". *Teaching Exceptional Children, 42*(4), 14-20.

Cramer, K. M., Collins, K., Snider, D., & Fawcett's, G. (2007). The virtual lecture hall: Utilization, effectiveness and student perceptions. *British Journal of Educational Technology, 38,* 106-115. doi:10.1111

Cuthell, J. P. (2006). Steering the supertanker: Transforming teaching and learning through the use of ICT. *Computers in the Schools, 23*(1/2), 99-110. doi: 10.1300/J025v23n01•09

D'Angelo, J. M., & Wooley, S. (2007). Technology in the classroom: Friend or foe. *Education, 127*(4), 462-471.

Data Recognition Corporation. (2010). *Technical report for the 2010 Pennsylvania System of School Assessment.* Retrieved from http://www.portal.state.pa.us/portal/server.pt

Davis, K. (2012). *The effects of technology instruction on the academic achievement of 5*th *grade students.* (Doctoral dissertation). Retrieved from http://digitalcommons.liberty.edu/doctoral/556

Deffenbaugh, D. G. (2010). Born digital: Understanding the first generation of digital natives - By John Palfrey and Urs Gasser. *Teaching Theology & Religion, 13*(4), 381-384. doi:10.1111/j.1467-9647.2010.00655.x

Digregorio, P., & Sobel-Lojeski, K. (2010). The effects of Interactive Whiteboards (IWBs) on student performance and learning: A literature review. *Journal of Educational Technology Systems, 38*(3), 255-312. doi:10.2190/ET.38.3.b

Di Martino, P., & Zan, R. (2010). ‘Me and maths’: Towards a definition of attitude grounded on students’ narratives. *Journal of Mathematics Teacher Education, 13*(1), 27-48. doi:10.1007/s10857-009-9134-z

Dreon, O., Kerper, R. M., & Landis, J. (2011). Digital storytelling: A tool for teaching and learning in the YouTube generation. *Middle School Journal, 42*(5), 4-9.

Dresel, M., & Haugwitz, M. (2008). A computer-based approach to fostering motivation and self-regulated learning. *Journal of Experimental Education, 77*(1), 3-20.

Dunleavy, M. M., Dexter, S. S., & Heinecke, W. F. (2007). What added value does a 1:1 student to laptop ratio bring to technology-supported teaching and learning? *Journal of Computer Assisted Learning, 23*(5), 440-452. doi:10.1111/j.1365-2729.2007.00227.x

Ediger, M. (2011). Assisting pupils in mathematics achievement (The Common Core Standards). *Journal Of Instructional Psychology, 38*(3/4), 154-156.

Fengfeng, K. (2008). Computer games application within alternative classroom goal structures: Cognitive, metacognitive, and affective evaluation. *Educational Technology Research & Development, 56*(5/6), 539-556. doi:10.1007/s11423-008-9086-5

4Sight Correlation Updates. (2008). *Pennsylvania and 4Sight*. Retrieved from www.pattan.net/files/4Sight/4SPA-nwsltr0308.pdf

Frye, N. E., & Dornisch, M. M. (2008). Teacher technology use and student evaluations: The moderating role of content area. *Journal of Educational Technology Systems, 36*(3), 305-317.

Furner, J. M., & Marinas, C. A. (2007). Geometry sketching software for elementary children: Easy as 1, 2, 3. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(1), 83-91.

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). *Educational research: An introduction* (7th ed.). Boston: Pearson/Allyn & Bacon.

Gardner, H. (1998). A multiplicity of intelligences. *Scientific American Presents,* 18-23.

Gardner, H. (2011). Promoting learner engagement using multiple intelligences and choice-based instruction. *Adult Basic Education & Literacy Journal*, *5*(2), 97-101.

Gersten, R., & Clarke, B. S. (n.d.). Effective strategies brief. *National Council of Teachers of Mathematics*. Retrieved from http://www.nctm.org/news/-content.aspx?id=8452.

Gillispie, L., Martin, F., & Parker, M. A. (2010). Effects of a 3-D video game on middle school student achievement and attitude in mathematics. [Article]. *Electronic Journal of Mathematics & Technology, 4*(1), 68-80.

Gorder, L. (2007). Creating classrooms of the future: Connecting classrooms with one-to-one computing. *Delta Kappa Gamma Bulletin*, *73*(4), 19-38.

Gorra, A., Finlay, J., Devlin, M., Lavery, J., Neagle, R., Sheridan-Ross, J. & Boyle, R. (2010). Learning with technology: What do students want? *Proceedings of the European Conference on E-Learning*, 126-133.

Gurian, M., & Stevens, K. (2004). With boys and girls in mind. *Educational Leadership, 62*(3), 21-26.

Gutek, G. (2005). *Historical and philosophical foundations of education*. Upper Saddle River, NJ: Pearson.

Hackman, M. Z., & Johnson, C. E. (1991). *Leadership: A communication perspective.* Prospect Heights, IL: Waveland Press.

Hadjerrouit, S. (2011). Using the interactive learning environment Aplusix for teaching and learning school algebra: A research experiment in a middle school. *Turkish Online Journal of Educational Technology, 10*(4), 384-389.

Hannula, M. S. (2006). Motivation in mathematics: Goals reflected in emotions. *Educational Studies in Mathematics*, *63*(2), 165-178. doi:10.1007/s10649-005-9019-8

Hansen, C. E., & Williams, M. R. (2003). Comparison of cross-cultural course changes: From traditional lecture course to contemporary course with biblio-learning, video-learning, and experiential exercises. *Journal of Instructional Psychology, 30*(3), 197-206.

Harlow, D., & Nilsen, K. (2011). Virtual inquiry experiences. *Science and Children, 49*(4), 42-45.

Hayden, K. (2008, August). Study Island helps improve test scores: Computerized data-driven, web-based program connects to standards. *Suite101.com: Online Magazine and Writers' Network.* Retrieved from http://suite101.com/article/study-island-helps-improve-test-scores-a64011

House, J. (2011). Effects of computer activities and classroom instructional strategies on science achievement of eighth-grade students in the United States and Korea: Results from the TIMSS 2007 assessment. *International Journal Of Instructional Media*, *38*(2), 197-208.

House, J. D., & Telese, J. A. (2011). Effects of computer activities and classroom lesson strategies on motivation for mathematics learning for eighth-grade students in the United States and Korea. *International Journal of Instructional Media, 38*(3), 295-306.

Huebner, T. A. (2010). Differentiated instruction. *Educational Leadership, 67*(5), 79-81.

Hunter, A. E. (2012). *The effects of computer assisted instruction and structured curriculum on struggling mathematics students*. (Doctoral dissertation, University of Louisville). ProQuest Dissertations and Theses, 220. Retrieved from http://search.proquest.com/docview/1151929885?accountid=12085. (1151929885)

Interactive Whiteboard. - The free encyclopedia. (n.d.). In Wikipedia, the free encyclopedia. Retrieved from http://en.wikipedia.org/wiki/Interactive_Whiteboard.

Kaufman, D. S. (2009). How does the use of interactive whiteboards affect teaching and learning? *Distance Learning, 6*(2), 23-33.

Kokoska, S. (2006). *Introductory statistics: A problem-solving approach*. Gordonsville, VA: W. H. Freeman.

Larkin, K., & Finger, G. (2011). Informing one-to-one computing in primary schools: Student use of net books. [Article]. *Australasian Journal of Educational Technology, 27*(3), 514-530.

Linder, S. M. (2012). Interactive whiteboards in early childhood mathematics. *YC: Young Children*, *67*(3), 26-35.

Lindstrom, P. P., Gulz, A. A., Haake, M. M., & Sjoden, B. B. (2011). Matching and mismatching between the pedagogical design principles of a math game and the actual practices of play. *Journal of Computer Assisted Learning*, *27*(1), 90-102.

Little, M. E. (2009). Teaching mathematics: Issues and solutions. *TEACHING Exceptional Children Plus, 6*(1), 1-15.

Maloy, R. W., Edwards, S. A., & Anderson, G. (2010). Teaching math problem solving using a web-based tutoring system, learning games, and students' writing. *Journal of STEM Education: Innovations & Research, 11*(1), 82-90.

Maninger, R. M., & Holden, M. (2009). Put the textbooks away: Preparation and support for a middle school one-to-one laptop initiative. *American Secondary Education, 38*(1), 5-33.

Manning, S., Stanford, B., & Reeves, S. (2010). Valuing the advanced learner: Differentiating up. *Clearing House, 83*(4), 145-149. doi:10.1080/-00098651003774851

Manny-Ikan, E., Tikochinski, T. B., Zorman, R., & Dagan, O. (2011). Using the Interactive Whiteboard in teaching and learning - An evaluation of the SMART CLASSROOM pilot project. [Article]. *Interdisciplinary Journal of E-Learning & Learning Objects, 7,* 249-273.

Martin, M. O., Mullia, I. V. S., & Foy, P. (2008). *TIMSS 2007 international mathematics report.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College. Retrieved from http://timss.bc.edu/timss2007/mathreport

Martindale, T., Pearson, C., Curda, L. K., & Pilcher, J. (2005). Effects of an online instructional application on reading and mathematics standardized test scores. *Journal of Research on Technology in Education, 37*(4), 349-360.

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

McAndrew, P. (2010). Defining openness: Updating the concept of "open" for a connected world. *Journal of Interactive Media in Education*. Retrieved from http://www.eric.ed.gov/PDFS/EJ910546.pdf

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

Miranda, H., & Russell, M. (2011). Predictors of teacher-directed student use of technology in elementary classrooms: A multilevel SEM approach using data from the USEIT study. *Journal of Research on Technology in Education, 43*(4), 301-323.

Murray, J. (2003). Contemporary literacy: Essential skills for the 21st century. *Information Today, Inc*. Retrieved from http://www.infotoday.com/mmschools/mar03/murray.shtml

Nagel, D. (2012). 'Math Map' connects 21st century skills with math instruction. *THE Journal: Technological Horizons in Education.* Retrieved from http://thejournal.com/articles/2012/04/11/math-map-connects-21st-century-skills-with-math-instruction.aspx

National Center for Educational Statistics. (2011). Table 142. *Percentage of students at or above selected mathematics proficiency levels, by age, sex, and race/ethnicity: Selected years, 1978 through 2008.* Digest of Education Statistics: 2011. Retrieved from http://nces.ed.gov/programs/digest/d11/tables/dt11_142.asp

National Council of Teachers of Mathematics. (2012). *Mission, vision and priorities*. Retrieved http://www.nctm.org/mission.aspx

National Council of Teachers of Mathematics. (n.d.). *Professional development focus of the year 2011-2012*. Retrieved from http://www.nctm.org/profdev/-content.aspx?id=30529

Neill, M., & Mathews, J. (2009). Does the use of technological interventions improve student academic achievement in mathematics and language arts for an identified group of at-risk middle school students? *Southeastern Teacher Education Journal, 2*(1), 57-65.

Nordness, P. D., Haverkost, A., & Volberding, A. (2011). An examination of hand-held computer-assisted instruction on subtraction skills for second grade students with learning and behavioral disabilities. *Journal of Special Education Technology, 26*(4), 15-24.

Orhun, N. N. (2007). An investigation into the mathematics achievement and attitude towards mathematics with respect to learning style according to gender. *International Journal of Mathematical Education in Science & Technology, 38*(3), 321-333. doi:10.1080/00207390601116060

Ozel, S., Ebrar Yetkiner, Z., & Capraro, R. M. (2008). Technology in K-12 mathematics classrooms. *School Science & Mathematics, 108*(2), 80-85.

Parkay, F. W., Hass, G., & Anctil, E. J. (2010). *Curriculum leadership* (9th ed.). Upper Saddle River, NJ: Pearson Education.

Partnership for 21st Century Skills (2011). *21st century skills map*. Retrieved from http://www.p21.org/storage/documents/P21_Math_Map.pdf

Pennsylvania Department of Education. (2012.). *2010 - 2011 PSSA and AYP results*. Retrieved from http://www.education.state.pa.us/portal/server.pt/-community/school_assessments/7442/2010-2011_pssa_and_ayp_results/1014980

Pennsylvania Department of Education Standards Aligned System. (2013). *Standards - View standards by subject area and grade level or course.* Retrieved from http://www.pdesas.org/Standard/Views

Pennsylvania State Education Association. (2007). *4Sight benchmark assessment*. [Professional Learning Exchange, Advisory]. Retrieved from www.psea.org/uploadedFiles/Publication

Persch, J. (2008). In Maine, a laptop for every middle-schooler. *District Administration, News, Articles and Community for K12 School District Management.* Retrieved from http://www.districtadministration.com/newssummary.aspx?-news=yes&postid=50517

Petscher, Y. (2010). A meta-analysis of the relationship between student attitudes towards reading and achievement in reading. *Journal of Research in Reading, 33*(4), 335-355. doi:10.1111/j.1467-9817.2009.01418.x

Piaget, J. (1964). PART I Cognitive development in children: Piaget. *Journal of Research in Science Teaching, 2*(3), 176-186.

Pierce, R., Stacey, K., & Barkatsas, A. (2007). A scale for monitoring students' attitudes to learning mathematics with technology. *Computers & Education, 48*(2), 285-300. doi:10.1016/j.compedu.2005.01.006

Plitt, T. (2008, August 1). 'Nation at Risk': The best thing or the worst thing for education? - *USAToday*.com. Retrieved from http://www.usatoday.com/news/education/2008-04-22-nation-at-risk_N.htm

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education, 130*(2), 241-250.

Prabhu, M. T. (2010). Technology adds to students' understanding of math. *Eschool News*, *13*(4), 18.

Qing, L., & Xin, M. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review, 22*(3), 215-243. doi:10.1007/s10648-010-9125-8

Ransdell, S., Kent, B., Gaillard-Kenney, S., & Long, J. (2011). Digital immigrants fare better than digital natives due to social reliance. *British Journal of Educational Technology, 42*(6), 931-938. doi:10.1111/j.1467-8535.2010.01137.x

Reed, H. C., Drijvers, P., & Kirschner, P. A. (2010). Effects of attitudes and behaviours on learning mathematics with computer tools. *Computers & Education, 55*(1), 1-15. doi:10.1016/j.compedu.2009.11.012

Reimer, K., & Moyer, P. S. (2005). Third-graders learn about fractions using virtual manipulatives: A classroom study. *Journal of Computers in Mathematics and Science Teaching, 24*(1), 5-25.

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

Ritzhaupt, A., Hohlfeld, T., Barron, A. E., & Kemker, K. (2008). Trends in technology planning and funding in Florida k-12 public schools. *International Journal of Education Policy and Leadership, 3*(8), 1-17.

Saine, N. L., Lerkkanen, M.-K., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2011). Computer-assisted remedial reading intervention for school beginners at risk for reading disability. *Child Development, 82*(3), 1013-1028. doi:10.1111/j.1467-8624.2011.01580.x

Salanova, M., Llorens, S., & Schaufeli, W. B. (2011). 'Yes, I can, I feel good, and I just do it!' On gain cycles and spirals of efficacy beliefs, affect, and engagement. *Applied Psychology: An International Review, 60*(2), 255-285. doi:10.1111/j.1464-0597.2010.00435.x

Schmoker, M. (2011). The stunning power of good, traditional lessons. *Phi Delta Kappan, 93*(4), 70-71.

Shenton, A., & Pagett, L. (2007). From ‘bored’ to screen: The use of the interactive whiteboard for literacy in six primary classrooms in England. *Literacy, 41*(3), 129-136. doi:10.1111/j.1467-9345.2007.00475.x

Sinclair, N., & Crespo, S. (2006). Learning mathematics in dynamic computer environments. *Teaching Children Mathematics, 12*(9), 437-444.

Suhr, K. A., Hernandez, D. A., Grimes, D., & Warschauer, M. (2010). Laptops and fourth-grade literacy: Assisting the jump over the fourth-grade slump. *Journal of Technology, Learning, and Assessment, 9*(5).

Sunha, K., & Mido, C. (2010). Computer games for the math achievement of diverse students. *Journal Of Educational Technology & Society, 13*(3), 224-232.

Szklarski, A. (2011). Pupils' experience of being motivated to learn in school: An empirical phenomenological study. *Teaching Science: The Journal of the Australian Science Teachers Association, 57*(1), 43-48.

Tienken, C. H., & Maher, J. A. (2008). The influence of computer-assisted instruction on eighth grade mathematics achievement. *Research in Middle Level Education Online*, *32*(3), 1-13.

Twenge, J. M. (2009). Generational changes and their impact in the classroom: Teaching Generation Me. *Medical Education, 43*(5), 398-405. doi:10.1111/j.1365-2923.2009.03310.x

Tyler, D., & Vasu, E. (1995). Locus of control, self-esteem, achievement motivation, and problem-solving ability: LogoWriter. *Journal of Research on Computing in Education, 28*(1), 98.

Uibu, K., & Kikas, E. (2008). The roles of a primary school teacher in the information society. [Article]. *Scandinavian Journal of Educational Research, 52*(5), 459-480. doi:10.1080/00313830802346348

U.S. Department of Education (2008). *A nation accountable: Twenty-five years after a nation at risk*, Washington, D.C. Retrieved from http://www2.ed.gov/rschstat/research/pubs/accountable/index.html

U.S. Department of Education (2012). *Understanding the implications of online learning for educational productivity*, Washington, DC Retrieved from http://www2.ed.gov/about/offices/list/os/technology/implications-online-learning.pdf

U.S. Department of Education (2013). *The condition of education 2013 (NCES 2013-037),* Washington, DC Retrieved from http://nces.ed.gov/pubsearch.

U.S. Department of Education (2013). *Fact sheet: Redesigning America's high school,.* Washington, DC. Retrieved from http://www.ed.gov/news/press-releases/fact-sheet-redesigning-americas-high-schools.

U.S. Department of Education, National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*, Washington, D.C. Retrieved from http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

U.S. Department of Education, Office of Special Education and Rehabilitative Services. (2000). *Archived information: A guide to the Individualized Education Program.* Retrieved from http://www2.ed.gov/parents/needs/speced/iepguide

Villano, M. (2007). A handful of learning. *T H E Journal*, *34*(12), 22-23.

Volpe, R. J., Burns, M. K., DuBois, M., & Zaslofsky, A. F. (2011). Computer-assisted tutoring: Teaching letter sounds to kindergarten students using incremental rehearsal. *Psychology in the Schools*, *48*(4), 332-342. doi:10.1002/pits.20557

Vygotsky, L. S., & Kozulin, A. (2011). The dynamics of the schoolchild's mental development in relation to teaching and learning. *Journal of Cognitive Education & Psychology*, *10*(2), 198-211. doi:10.1891/19458959.10.2.198

Wadlington, E., & Wadlington, P. (2008). Helping students with mathematical disabilities to succeed. *Preventing School Failure, 53*(1), 2-7.

Wang, K. H., Wang, T. H., Wang, W. L., & Huang, S. C. (2006). Learning styles and formative assessment strategy: Enhancing student achievement in Web-based learning. *Journal of Computer Assisted Learning, 22*(3), 207-217. doi:10.1111/j.1365-2729.2006.00166.x

Weiss, R. (2000). Howard Gardner talks about technology. *Training & Development*, *54*(9), 52.

Wijekumar, K., Hitchcock, J., Turner, H., Lei, P., Peck, K. (2009). *A multisite cluster randomized trial of the effects of CompassLearning Odyssey[R] Math on the math achievement of selected grade 4 students in the mid-Atlantic region.* (NCEE 2009-4068.) Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Yixin, Z. (2011). Investigating effectiveness of using handheld computers in elementary students' learning mathematics. *National Forum Of Teacher Education Journal*, *22*(1/2), 14-24.

Yücel, Z., & Koç, M. (2011). The Relationship between the prediction level of elementary school students' math achievement by their math attitudes and gender. (English). *Ilkogretim Online, 10*(1), 133-143.

Yudt, K., & Columba, L. (2011). Interactive whiteboards: A tool for enhancing teaching and learning. *Journal of Technology Integration in the Classroom, 3*(2), 17-22.

Yuen-kuang Cliff, L., Huei-wen, C., & Yu-wen, C. (2007). Effects of computer applications on elementary school students' achievement: A meta-analysis of students in Taiwan. *Computers in the Schools, 24*(3/4), 43-64. doi: 10.1300/J025v24n0304.

Yu-Ju, L., Yao-Ting, S., Ning-chun, T., Chiu-Pin, L., & Kuo-En, C. (2010). Mobile-device-supported problem-based computational estimation instruction for elementary school students. *Journal of Educational Technology & Society, 13*(3), 55-69.

Zardoya, I., & Fico, M. (2001). Urban students cross the digital divide through laptop leasing program. *Education, 122*(2), 262.

Appendix A

ELSEVIER LICENSE

TERMS AND CONDITIONS

Jun 28, 2013

This is a License Agreement between Traci Shoemaker ("You") and Elsevier ("Elsevier") provided by Copyright Clearance Center ("CCC"). The license consists of your order details, the terms and conditions provided by Elsevier, and the payment terms and conditions.

All payments must be made in full to CCC. For payment instructions, please see information listed at the bottom of this form.

Supplier	Elsevier Limited The Boulevard,Langford Lane Kidlington,Oxford,OX5 1GB,UK
Registered Company Number	1982084
Customer name	Traci Shoemaker
Customer address	801 Appledale Lane
	Duncansville, PA 16635
License number	3092701289672
License date	Feb 19, 2013
Licensed content publisher	Elsevier
Licensed content publication	Computers & Education
Licensed content title	A scale for monitoring students' attitudes to learning mathematics with technology
Licensed content author	Robyn Pierce,Kaye Stacey,Anastasios Barkatsas
Licensed content date	February 2007
Licensed content volume number	48
Licensed content issue number	2
Number of pages	16
Start Page	285
End Page	300

Type of Use	reuse in a thesis/dissertation
Portion	excerpt
Number of excerpts	1
Format	print
Are you the author of this Elsevier article?	No
Will you be translating?	No
Order reference number	
Title of your thesis/dissertation	Effect of Computer-Aided Instruction on the Attitude and Achievement of Fifth Grade Math Students
Expected completion date	Jul 2013
Estimated size (number of pages)	150
Elsevier VAT number	GB 494 6272 12
Permissions price	0.00 USD
VAT/Local Sales Tax	0.00 USD / 0.00 GBP
Total	0.00 USD
Terms and Conditions	

Appendix B

Recruitment Letter

Date: January 28, 2013

Dear Parents/Guardians:

As a graduate student in the Education Department at Liberty University, I am conducting research as part of the requirements of my doctorate degree, and I am inviting your child to participate in my study.

If you choose to have your child participate, he/she will be asked to take the 4Sight Math assessment, which is already an assessment that is required by the Spring Cove School District to monitor math progress. Your child will also be asked to complete an attitude survey regarding his/her feelings toward math and the use of computers in learning math concepts. If you agree to have your child participate, he/she will have the opportunity to use computers more frequently in math lessons, set goals in math, and receive feedback about his/her progress in math. Your child's participation will be completely anonymous and no personal, identifying information will be required. Only your child's school identification number will be used on assessment forms and surveys.

An informed consent document is attached to this letter. The informed consent document contains additional information about my research. Please sign the attached document and return it to me as soon as possible to indicate that you have read it and would allow your child to take part in this study.

Sincerely,

Mrs. Traci Shoemaker

3rd Grade Teacher

Martinsburg Elementary School

Appendix C

____________________________ ____________________________

Parent/Guardian's Name Child's Name

Parent /Guardian Consent Form

Study Title: "Effect of Computer-aided Instruction on Attitude and Achievement of Fifth Grade Math Students"

Introduction

Your child is invited to participate in a research study entitled "Effect of Computer-aided Instruction on Attitude and Achievement of Fifth Grade Math Students." The study is being conducted by Traci Shoemaker, a doctoral student at Liberty University, as her final dissertation. Your child was selected because he/she is a member of the fifth grade class.

Purpose of the Study

The purpose of the study is to see if using technology as part of the mathematics curriculum helps to improve students' attitude toward math learning. It will also assess the effectiveness of computer-aided instruction in helping your child to learn and apply math concepts at his/her instructional level.

Procedures

If your child participates in this study he/she will:

* continue to receive traditional instruction in math, following district and state standards

* use Study Island, leveled to meet his/her instructional needs, three times each week for 20 minutes as a supplement to the regular math instruction for seven of the fourteen weeks of the study

*answer questions on a survey about his/her attitude and view of math and using computers in math- survey is expected to take approximately 20 minutes to administer

*take the 4Sight Math assessment (an assessment already used by the district) – the time allotted for this assessment is one hour, plus time to pass out and collect materials

Duration and Location of the Study

The study will begin in January 2013 and last approximately fourteen weeks. All activities will take place either in your child's classroom or in the computer lab.

Potential Risks and Discomforts

Possible risk involved includes your child being uncomfortable answering questions about his/her feelings about math, his/her ability in math and how he/she views technology. The researcher will remind your child that answers are totally confidential and no one will be able to tell how he/she answered the questions since no names are attached to the survey.

Potential Benefits

Your child will be given increased opportunity to use technology as part of his math instruction. He/she will be encouraged to set goals and use the feedback from the computer program to monitor his learning and increase his progress in math. Instruction will be leveled so that it meets your child's level of achievement and the game options will be used when your child has met his/her goal to increase motivation.

The results of this study will help the researcher to determine if computer-aided instruction used in this way is enjoyable and worthwhile for helping all students learn.

Compensation

Students will receive no compensation for participating in the study.

Confidentiality

Information about your child will not be released or discussed at any time. At the outset of the study, your child will be asked to use his identification number on all surveys and assessments. The identification numbers and your child's name will be kept confidential in the researcher's files, locked in a filing cabinet. All records and information collected on the computer will be password protected.

Participation and Withdrawal

You can choose whether you want your child to participate in this study or not. If you volunteer him/her for this study, you may withdraw him/her at any time without consequences of any kind. Withdrawal or refusal will not affect your relationship or your child's relationship with the school, the classroom teacher, the researcher, or Liberty University.

Contact Information

If you have any questions or concerns, please feel free to contact me now or at any time throughout the study.

Researcher's name: Traci Shoemaker

Phone: (814) 793-2014

E-mail: tshoemaker2@liberty.edu

Faculty Advisor: Dr. Gary Woods

Phone: (619) 590-2141

E-mail: gwoods2@liberty.edu

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24502 or email at irb@liberty.edu.

Signature of Legal Representative (Parent/Guardian)

I understand the procedures and conditions of my child's participation described above. My questions have been answered to my satisfaction, and I agree to let him/her participate in this study. I have been given a copy of this form.

_______________________________________ _________________________

Parent/Guardian's signature Date

Signature of Investigator:___________________________ Date: ___________________

IRB Code Numbers: 1521 **IRB Expiration Date:** Jan. 2014

Appendix D

Child's Agreement to Take Part in a Research Study

What is the name of the study and who is doing the study?

The study is titled, "The Effect of Computer-aided Instruction on Attitude and Achievement of Fifth Grade Math Students." It is being conducted by Mrs. Traci Shoemaker, a third grade teacher at Martinsburg Elementary School.

Why am I doing this study?

I am interested in studying the effect of using computers, Study Island, on the attitude and achievement of fifth grade math students. I want to see if using this program more frequently, and changing it to match each student's math level will help him/her to score higher on math assessments like the 4Sight math assessment. I am also interested in finding out if using Study Island in this way helps students to enjoy learning math and helps them gain more confidence in learning math while using computers.

Why am I asking you to be in this study?

You are being asked to be in this research study because you are a fifth grade student in the Spring Cove School District. This district has agreed to participate in this study and has the resources to support the technology used in the project.

If you agree, what will happen?

If you are in this study you will take the 4Sight math assessment as usual. In addition, you will be asked to complete an attitude survey about your feelings regarding math and using computers. You will also get the opportunity to use computers more frequently during this study for math instruction.

Do you have to be in this study?

No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher will not be angry. You can say yes now and change your mind later. It's up to you.

Do you have any questions?

You can ask questions any time. You can ask now. You can ask later. You can talk to the researcher. If you do not understand something, please ask the researcher to explain it to you again.

Signing your name below means that you want to be in the study.

________________________________ ________________________

Signature of Child Date

Researcher's name: Traci Shoemaker

Phone: (814) 793-2014

E-mail: tshoemaker@scsd.k12.pa.us

Faculty advisor's name: Dr. Gary Woods

Phone: (619) 590-2141

E-mail: gwoods2@liberty.edu

Liberty University Institutional Review Board,

1971 University Blvd, Suite 1837, Lynchburg, VA 24502

or email at irb@liberty.edu.