THE RELATIONSHIP BETWEEN USING *STUDY ISLAND* SUPPLEMENTAL MATH SOFTWARE AND THIRD, FOURTH AND FIFTH GRADE STUDENTS' MATHEMATICS ACHIEVEMENT

by

Michael John Rich

Liberty University

A Dissertation Presented In Partial Fulfillment

of the Requirements for the Degree

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ABSTRACT

The ex post facto study investigated the relationship between the use of *Study Island* supplemental math software and students' math achievement in a Title I public elementary school in Georgia during the 2011-2012, 2012-2013, and the 2013-2014 school years. Data from the school was collected regarding the use of a supplemental math software program called *Study Island* during the 2012-2013 and the 2013-2014 school years. Data on students' math achievement test scores was collected from school level reports for the 2011-2012, 2012-2013, and the 2013-2014 school years. Data was analyzed using a two-tailed *t* test to investigate the possible relationship between the use of the supplemental math software and students' math achievement. Study results can be used to inform current school curriculum leaders, administrators, and teachers as they invest in technology tools and integrate technology into the math classroom. Results could also help schools of educational leadership working with finance, curriculum and instructional leaders, schools of educational technology, and teacher preparation academies as they train educators to effectively integrate technology into the classroom.

Keywords: instructional technology, math achievement, math software, instructional software, online courseware

DEDICATION

I would like to dedicate this work to my best friend and wife, Paula. Thank you for believing in me and supporting me on this long journey.

Acknowledgements

I would first like to thank my Lord and Savior, Jesus Christ. I am forever grateful for the opportunity to use my time and talents in ministering to the needs of children.

I would also like to acknowledge my committee members for their encouragement, guidance and wisdom: thank you Dr. Shante Moore Austin, Dr. Mary Garzon, and Dr. Kim Nichols.

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Table of Contents

List of Tables

CHAPTER ONE: INTRODUCTION

Background

School leaders have increasingly turned to technology to improve schools and increase student achievement. A 1998 survey revealed that approximately 8.6 million computers were in K-12 classrooms, a number that was growing about 15 percent per year (Becker, 2001). While school leaders have placed more computers and technology in schools each year, they have been divided on where to place them. In a 1999 study, schools were found to have split computers about evenly between classrooms and computer labs (Anderson & Ronnkvist, 1999). A more recent study revealed that 37.1% of computers were placed in the classroom, 34% placed in computer labs, with the remaining placements divided among wireless laptop labs, portable computing devices, and other configurations (Hayes & Greaves, 2008).

The Georgia Department of Education has been a leader in funding classroom technology for the past fifteen years in public schools across the state. With the passage of a state lottery in 1993, the state began funding classroom technology with lottery proceeds for every public school district in the state (Georgia Lottery Corporation, 2009). From 1993 to 2003, lottery proceeds funded 1.3 billion dollars' worth of new technology initiatives in public schools in the state (Georgia Lottery Corporation, 2008). With the exclusion of educational technology from lottery based funding in 2003, school districts have had to use local funds and grant funds to continue technology initiatives in schools. Despite this loss of funding at the local level, schools in Georgia continue to increase students' access to and use of technology, according to a recent report by Education Week (2009). While investing technology funds in an era of increasing accountability, school leaders in Georgia looked to educational research to ensure wise investments that would result in increased student achievement.

Although classroom computers have been implemented in public schools in a myriad of ways for the past thirty years, the vision of technology transforming teaching and learning has remained largely unfulfilled. When faced with limited resources, educational leaders have been hard pressed to find research-based proven models of technology integration that lead to increased student achievement. Faced with this lack of research, schools and school systems often invest in technology based on promises from technology vendors, rather than on research-based implementation strategies.

Problem Statement

The problem is that school leaders do not have sufficient research results regarding the relationship between the use of recent educational software and student achievement to guide them in making investments in technology. When budgeting for technology investments, educational leaders must often make choices between competing brands and types of hardware and software. While few would argue that technology has become an increasingly ubiquitous facet of modern American life, their impact on teaching and learning in the classroom is less clear.

Purpose Statement

The purpose of the study was to investigate the possible relationship between using *Study Island* supplemental math software and student mathematics achievement in third through fifth grade math classrooms in a Title I public school in Georgia. A recent review of literature suggests that few studies of recently available technology in elementary school classrooms and its impact on student mathematics achievement have been conducted (Beal, Walles, Arroyo, & Woolf, 2007; Salerno, 1995; Dunleavy & Heinecke, 2007). While computer technology and software have been common additions to many classrooms over the past few decades, educators have limited evidence of their effects on student learning. While studies on educational technology have been prevalent for several decades, the pace of technological innovation, the unique features of local schools in different communities, and the need to provide equitable access to technology resources to all students often limit the applicability of the findings of the research on educational technology to specific applications in the present. Nevertheless, educational leaders at all levels continue to invest in technology innovations for classrooms.

The Georgia Department of Education released several white papers in 2008 outlining best practices for integrating technology into schools to increase student achievement (Harris & Callier, 2008; Giddens, 2008; Fore, 2008). While these white papers offer school and system leaders advice on how to implement technology into the classroom, they do not investigate the relationship between technology use and student achievement. Rather, the primary focus of the Georgia Department of Education white papers is on how to ensure that teachers successfully implement the new technology (Harris & Callier, 2008; Giddens, 2008). The Georgia Department of Education also provided school systems with a guide to creating "21st Century Learning Environments" (Georgia Department of Education, 2008). According to the Georgia Department of Education, "A successful 21st Century learning environment has the potential to engage students in meaningful, relevant learning that will help prepare them for competing in a global society and ultimately increase student success" (2008a). The document also contains a list of hardware components (mounted projector, mounted interactive whiteboard, student response system, etc.) that should be provided in a 21st Century Learning Environment (2008a). What the document lacks is research investigating how the new hardware and new software impacts student achievement.

Without scientific research documenting the results of technology in the classroom, school leaders have been asked to invest significant funds to make these resources available to more students while not knowing if and how these investments will likely affect student achievement. Despite this uncertainty, school leaders have historically chosen to spend significant sums of money in technology based on the potential for positive impacts on student achievement. While this trend is unlikely to change given the increasing uses of technology in American society, educational leaders do need abundant research into the effect of technology on student achievement.

Significance of the Study

Currently, inadequate educational research exists documenting the relationships between the use of *Study Island* supplemental math software and student achievement in the elementary school classroom. This study could add to the growing body of research in this area. By investigating the relationship between using supplemental math software on students' math achievement in a Title I elementary school over the course of an entire academic year for two subsequent years, the study represents a potentially significant research effort that could shape future educational research studies that are more experimental in design to investigate possible relationship between specific technology uses in elementary school classrooms. While these potential future investigations may be more experimental in design, they may also be conducted on a larger scale than this study, and thus less subject to limitations due to small sample sizes, unique research contexts, and other effects like history and subject maturation.

The researcher currently serves as an elementary school principal and former Director of Technology for a public school system in Georgia. In his current position, the researcher is interested in the study's results to help inform educational leaders regarding technology innovations. The researcher currently has access to other educational leaders, on a local and state level, who make decisions on technology funding. Through formal and informal contacts with other educational leaders, the researcher is often reminded of the need for research like this study throughout school systems in the state.

Educational leaders find themselves in the position of investing public funds in resources in order to improve student achievement. While school system budgets often number in the millions of dollars, no educational leader has unlimited financial resources. Educational leaders must make choices, then, between competing interests for educational dollars.

Given the current lack of research regarding the effectiveness of recently available educational technology and the relatively high costs of implementing and maintaining classroom technology, educational leaders are often forced into choosing technology innovations based more on their potential to impact student achievement, rather than results from research showing if and how technology investments impact student achievement.

Study results from this study could inform current school curriculum leaders, elementary administrators, and elementary teachers as they invest in technology tools for the math classroom. Results could also help schools of educational leadership working with finance, curriculum and instructional leaders, schools of educational technology, and teacher preparation academies as they train educators to integrate technology effectively into the classroom.

As an educational leader with a Christian worldview, the researcher is keenly aware of the need for integrity in investing public funds to help students. In addition to holding the potential to improve student achievement, technology has tremendous possibilities for students and teachers alike to teach and learn lessons, lessons that can be secular or God-centered. Even becoming a wise steward of funds and using research, rather than excitement, to make budgeting decisions can be an essential lesson for living in accordance with God's word. As an educational leader, the researcher recognizes that students, parents, teachers, and others learn from a leader's actions and decisions as much as from his words. As one called to teaching, one tries daily to obey God's command to "teach them diligently unto thy children, and … talk of them when thou sittest in thine house, and when thou walkest by the way, and when thou liest down, and when thou risest up" (Deuteronomy 6:6-8, King James trans.).

Objectives of the Study

The objectives of this study include the following:

1. To examine the use of *Study Island* math software in third, fourth and fifth grade math classrooms in a Title I elementary school.
2. To examine the level of math achievement among public elementary school students in Georgia.
3. To determine if the use of supplemental math software in public elementary school classrooms in a Title I elementary school in Georgia had an effect on the level of math achievement among elementary school students.

Research Questions

To investigate the relationship between the use of *Study Island* math software and the math achievement scores of third, fourth, and fifth grade students, the researcher proposed the following research questions.

RQ1: Is the use of *Study Island*, a supplemental software program, correlated to students' mathematics achievement?

RQ2: Is the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?

Null Hypotheses

The first research question this study sought to address whether the use of *Study Island,* a supplemental software program, was correlated to students' mathematics achievement. The following sets of hypotheses were proposed to test research question one.

The corresponding research hypotheses are: (Hypothesis 1) Third grade students who use *Study Island* supplemental math software will have higher levels of math achievement than third grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Third grade students who use *Study Island* supplemental math software will have lower levels of math achievement than third grade students who do not use supplemental math software. The null hypothesis is: Third grade students who use *Study Island* supplemental math software will have the same levels of math achievement as third grade students who do not use supplemental math software.

Hypothesis 2 states: Fourth grade students who use *Study Island* supplemental math software will have higher levels of math achievement than fourth grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Fourth grade students who use *Study Island* supplemental math software will have lower levels of math achievement than fourth grade students who do not use supplemental math software. The null hypothesis is: Fourth grade students who use *Study Island* supplemental math software will have the same levels of math achievement as fourth grade students who do not use supplemental math software.

Hypothesis 3 is: Fifth grade students who use *Study Island* supplemental math software will have higher levels of math achievement than fifth grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Fifth grade students who use *Study Island* supplemental math software will have lower levels of math achievement than fifth grade students who do not use supplemental math software. The null hypothesis is: Fifth grade students who use *Study Island* supplemental math software will have the same levels of math achievement as fifth grade students who do not use supplemental math software.

The second research question sought to address whether the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?

The research hypotheses for question 2 are: (Hypothesis 4) Third grade students who use *Study Island* supplemental math software in the second implementation year will have higher levels of math achievement than third grade students who do not use supplemental math software. The alternative hypothesis is: Third grade students who use *Study Island* supplemental math software in the second implementation year will have lower levels of math achievement than third grade students who do not use supplemental math software. The null hypothesis is: Third grade students who use *Study Island* supplemental math software in the second implementation year will have the same levels of math achievement as third grade students who do not use supplemental math software.

Hypothesis 5 states: Fourth grade students who use *Study Island* supplemental math software in the second implementation year will have higher levels of math achievement than fourth grade students who do not use supplemental math software. The alternative hypothesis is: Fourth grade students who use *Study Island* supplemental math software in the second implementation year will have lower levels of math achievement than fourth grade students who do not use supplemental math software. The null hypothesis is: Fourth grade students who use *Study Island* supplemental math software in the second implementation year will have the same levels of math achievement as fourth grade students who do not use supplemental math software.

Hypothesis 6 is: Fifth grade students who use *Study Island* supplemental math software in the second implementation year will have higher levels of math achievement than fifth grade students who do not use supplemental math software. The alternative hypothesis is: Fifth grade students who use *Study Island* supplemental math software in the second implementation year will have lower levels of math achievement than fifth grade students who do not use supplemental math software. The null hypothesis is: Fifth grade students who use *Study Island* supplemental math software in the second implementation year will have the same levels of math achievement as fifth grade students who do not use supplemental math software.

Identification of Variables

The dependent variable student math achievement was generally defined as scaled scores on the math portion of the statewide standardized Criterion Referenced Competency Test for two subsequent years for the same students.

The independent variable was defined as the use of the supplemental math software program *Study Island*. For the study, all students who were present during the full academic year as defined by state guidelines during the 2011-2012 school year were included in the control group. Similarly, students who were present for the full 2012-2013 academic year (first year of software implementation) comprised one experimental group, and students who were present during the 2013-2014 academic year (second year of implementation) comprised a second experimental group. The students present during the 2012-2013 and 2013-2014 school years had the opportunity to use the supplemental math software throughout the year before the administration of the state standardized test.

For the purpose of this study, supplemental math software use was defined as the opportunity to use the supplemental math software at least once per week for at least 20 minutes over the course of 30 weeks in the school year before the state standardized testing.

The operational definition of students' math achievement was the scaled score on the math portion of the Georgia Criterion Referenced Competency Test.

Assumptions and Limitations

In conducting this study, the researcher made a number of research assumptions. First, it was assumed that students' scores on the mathematics portion of the Georgia Criterion Referenced Competency Test (CRCT) are actually indicative of their academic achievement in math. This assumption could be false at the level of the individual student, the class, or the school due to the possible effects of a number of factors, including illness, environmental conditions during testing, and cheating. While school administrators and teachers take numerous precautions against these factors affecting students' performances on standardized tests such as the CRCT, this researcher recognizes that a given student's score on any standardized test may or may not be an accurate measure of his or her academic achievement.

A second assumption in this study was that students actually used the online supplemental math software in the teaching and learning of mathematics in a significant manner. Since 2006, the state of Georgia has required all public school teachers to either take a state approved course in using classroom technology as part of the teaching and learning process or to pass a state test of technology competency (Georgia Professional Standards Commission, 2001). While the teachers in the math classrooms included in the study have demonstrated competency in using technology, the researcher acknowledges that the amount and manner technology is used in the math classroom may vary widely even when teachers and students have access to the same instructional software and computer hardware. For example, teachers with the same number of classroom computers, software programs, and minutes in their schedule may allow students to use the computers only for rewards after completing the “real work” of learning tasks, as remediation for previously learned concepts, or as independent extensions for students who have already mastered specific learning content. In this way, the researcher acknowledges, variability in both the quantity and quality of the use of technology by students may weaken the results of the study. The program *Study Island* attempts to control for these quantitative and qualitative differences by measuring the amount of time students spend in each learning module and by requiring students to answer at least 70% of items on a post module quiz correctly.

The variation in the use of the supplemental math software program could limit the findings of this study. Use of the software was defined as the opportunity to use the software during the academic year. Usage reports from the software were analyzed to create findings about the fidelity of implementation, using features of the program such as student time on task in each module. The software program defines successful completion of each module as attainment of at least a 70% average accuracy on the formative assessment in each module. Teachers monitored students’ use by reviewing usage reports periodically to ensure students were progressing through the modules in a satisfactory manner (L. Welborn, personal communication, Sep. 23, 2013). In the school in the study, students worked on the program during a weekly computer lab time, in the math classroom after completing lessons, and at home via a web-based interface (L. Welborn, personal communication, Sep. 23, 2013). Since students attended computer lab sessions each week for approximately 40 minutes over the course of approximately 31 weeks before taking the CRCT test, the researcher concluded that students had ample time to complete modules in the program over the course of the school year (L. Welborn, personal communication, Sep. 23, 2013). Math teachers, the computer lab teacher, and the school’s academic coach reviewed benchmark data from the school’s benchmark tests as well as weekly formative data from classroom assessments to identify students who were at risk in math (L. Welborn, personal communication, Sep. 23, 2013). These at-risk students were offered an additional session in the computer lab each week to work in the program (L. Welborn, personal communication, April 8, 2014). Since teachers only reviewed the data every few weeks, another limitation of the study was that students who began to struggle with a particular unit of study or set of math concepts during the middle of the year were not offered the extra sessions with the program nor individualized help more immediately.

A third assumption in the study was that the sample of third, fourth and fifth grade math classrooms in the Title I public elementary school selected for the study is reflective of the population of all elementary school math students in Georgia and, in a larger sense, in the United States of America. Given the widely varying nature of a number of significant factors, including district curriculums, state standards, state standardized tests, student demographics, and educational funding, this assumption may limit the generalizability of the findings to schools, districts, and states with similar educational structures and student populations.

Organization of the Study

The study consists of five chapters, a bibliography, and appendices. Chapter two contains a review of literature c presents the summary, conclusions, implications, and recommendations of the study. The study concludes with a bibliography and appendices.

CHAPTER TWO: LITERATURE REVIEW

Introduction

The literature review for the proposed study is organized into three broad sections. First, a section summarizing the historical and current calls to integrate technology into the mathematics classroom in public schools in the United States will be presented. Next, an overview of the uses of technology in the mathematics classroom over the past half century will be provided. Finally, several theoretical models currently used to guide technology integration in the elementary school mathematics classroom will be presented.

Political Calls for Technology in the Classroom

When running for president of the United States in 2008, Barack Obama promised that his education policy would focus on improving access to technology for students and on improving student achievement in technology, science, and math (Obama for America, 2008). According to an article entitled, “Barack Obama: Connecting and Empowering All Americans through Technology and Innovation,” Obama outlined his plan to “upgrade education to meet the needs of the 21st century” (2008). According to the document, “Access to computers and broadband connections in public schools must be coupled with qualified teachers, engaging curricula, and a commitment to developing skills in the field of technology” to ensure that “all public school children are equipped with the necessary science, technology and math skills to succeed in the 21st century economy” (2008).

President Obama’s predecessor, George W. Bush, commissioned a panel of experts in 2006 to recommend how to improve math education in the United States with the goal of increasing American competitiveness in a global economy (National Mathematics Advisory Panel, 2008). According to the panel’s findings, instructional software “has generally shown positive effects on students' achievements in mathematics …" (p. xxiii). Further, the panel concluded that "drill and practice and tutorials can improve student performance in specific areas of mathematics" (p. xxiii). Teaching computer programming to students, according to the panel, "can support the development of particular mathematical concepts, applications, and problem solving" (p. xxiii). The panel found limited evidence of the benefits of using calculators in the classroom, especially in the elementary and middle grades (p. xxiv). Finally, the panel called for more educational research on the effects of using technology in the math classroom (2008).

Initiatives for significant investments in educational technology are not limited to the federal level of educational leadership. The Georgia Department of Education has been a leader in funding classroom technology for the past fifteen years in public schools across the state. With the passage of a state lottery in 1993, the state began funding classroom technology with lottery proceeds for every public school district in the state (Georgia Lottery Corporation, 2009). From 1993 to 2003, lottery proceeds funded 1.3 billion dollars of new technology initiatives in public schools in the state (Georgia Lottery Corporation, 2008).

The Georgia Department of Education released several white papers in 2008 outlining best practices in integrating technology into schools to increase student achievement (Harris & Callier, 2008; Giddens, 2008; Fore, 2008). While these white papers offer school and system leaders advice on how to implement technology into the classroom, they do not investigate the relationship between technology on student achievement. Rather, the focus of most of the Georgia Department of Education white papers is on how to ensure that teachers successfully implement the new technology (Harris & Callier, 2008; Giddens, 2008). The Georgia Department of Education also provided school systems with a guide to creating "21st Century Learning Environments" (Georgia Department of Education, 2008). According to the Georgia

Department of Education, “A successful 21st Century learning environment has the potential to engage students in meaningful, relevant learning that will help prepare them for competing in a global society and ultimately increase student success” (2008a). The document also contains a list of hardware components (mounted projector, mounted interactive whiteboard, student response system, etc.) that should be provided in a 21st Century Learning Environment (2008a). What the document lacks is research investigating how the new hardware impacts student achievement.

Professional Recommendations for Technology in the Classroom

In his work, *The World is Flat*, journalist Thomas Friedman argues that American students will need to become proficient in using all sorts of technology to compete economically as adults with workers in other countries (2005). According to Friedman, workers in the future will use computers, the Internet, community developed open source software, and Web 2.0 tools such as Wikis, blogs, and podcasts to collaborate and produce information (p. 95). Rather than being intimidated by these new possibilities as many adults are, students today seem to embrace the opportunity to collaborate online, since they have literally grown up with computers and the Internet (p. 119). In addition to technological innovations, Friedman argues for several significant changes to improve math achievement for American students, including changes in educational funding (p. 160), more mathematical training for teachers (p. 353), and more student time spent in learning and studying, rather than in “watching television and surfing the Internet” (p. 354).

The largest group of math educators in the United States also recommends using technology in the math classroom. The National Council of Teachers of Mathematics calls on students to master technology as part of the math curriculum (2009). According to the organization, students in grades three through five should "select appropriate methods and tools for computing with whole numbers from among mental computation, estimation, calculators, and paper and pencil according to the context and nature of the computation and use the selected method or tools" (p. 3). The use of computers and computer software could be viewed as a tool for computing, in line with the recommendation from NCTM. The elementary and middle school use of technology, according to the NCTM, will lead high school students to be able to "develop fluency in operations with real numbers, vectors, and matrices, using mental computation or paper-and-pencil calculations for simple cases and technology for more-complicated cases" (p. 3).

Educational researchers have also urged educators to integrate technology into the mathematics classroom over the past few decades. According to an extensive review of research literature commissioned by the National Council of Teachers of Mathematics, "There is ample evidence that use of various forms of technology may enhance student understanding of mathematics" (Zbiek and Hollebrands, 2008, p. 287). The Association for Educational Communications and Technology, working with the National Council for Accreditation of Teacher Education, has released technology standards for colleges working to prepare students to enter schools as technology teachers, media specialists, and technology specialists since 1974 (2001). The International Society for Technology in Education has released standards and performance indicators for all classroom teachers to describe best practices for how to use technology (2008). The Partnership for 21st Century Skills, a nonprofit group of educators, government agencies, business leaders, and community leaders formed in 2002, calls for schools to teach information, media, and technology skills to help students prepare for work in the next few decades (2004).

Despite calls for using educational technology from numerous sources over the past few decades, actually getting classroom teachers to integrate technology in the classroom continues to be an elusive goal. Part of this lack of significant technology integration in many classrooms may have to do with differing definitions of educational technology among politicians, administrators, researchers, and classroom teachers. Lever-Duffy and McDonald define educational technology as “the full range of media that a teacher might use to enhance his or her instruction and augment student learning” (p. 5).

Student-centered Uses of Classroom Technology

While classroom technology is still not consistently pervasive throughout math classrooms in the United States, many tools have been introduced of the past few decades (Anderson & Ronnqvist, 1999). According to Drijvers and Trouche, “Currently, programming languages, graphing software, spreadsheets, geometry software, computer algebra systems, and other kinds of new tools for the learning of mathematics are widely disseminated” (2008, p. 363).

Most uses of technology in the classroom over the past forty years have sought to shift the center of instruction from the teacher to a more student centered, experiential approach by using available technology. According to Jeanne Ormond, in teacher centered instruction, the teacher “calls most of the shots, choosing what topics will be addressed, directing the course of the lesson, and so on … .” (2006, p. 435). Student centered instruction, on the other hand, allows students to “have considerable say in the issues they address and how to address them” (p. 435).

Many forms of educational technology are deliberate attempts to change instruction from teacher centered to more student centered. While Seymour Papert argues that computer aided instruction or tutorial programs are merely the substitution of a computer program for a teacher (2003b), the ability of these types of programs to provided individualized lessons to each student based on the results of diagnostic assessments makes them more student centered than traditional classrooms in which a teacher delivers the same lesson content to all students simultaneously. Although most classrooms are not, and should not be, entirely teacher centered or entirely student centered (National Mathematics Advisory Panel, 2008), classroom technology has the potential to shift the balance of classroom instruction toward more student centered activity more of the time.

Computer Aided Instruction

Early in the history of classroom computing, many schools invested in computer labs and Computer Aided Instruction, sometimes called Integrated Learning Systems (Wood, 1998; Kulik, 2002; Roll, Aleven, McLaren, & Koedinger, 2007). By identifying a student's level of performance and delivering instruction on the level just above that, proponents of Computer Aided Instruction hoped that a room full of students working on computers could all learn more efficiently than they could if exposed to instruction on a single level from a classroom teacher. Computer drill and practice programs, a subset of Computer Aided Instruction programs, hope to help students master math computational skills, such as memorization of math facts (p. 296). In a 1991 meta-analysis of 254 studies, Kulik and Kulik found that computer-based instruction generally produced positive effects on student achievement (1991). In this model of technology integration, the computer essentially replaces the classroom teacher as the source of information and instruction, a model that has "smaller and less consistent achievement effects," than when it is used in addition to regular classroom instruction (p. 299). In a more recent meta-analysis of 16 studies, James Kulik found that use of an Integrated Learning System for drill and practice and supplemental tutoring resulted in significant math achievement gains for students (2002). Kulik points out that many of the studies reviewed contained less than ideal implementations of the technology within the math classroom, resulting from too little time spent on allowing students to use the software (2002). According to Kulik, “Evaluation results might have been even better if evaluators had focused on model implementation rather than on typical ones” (p. 2).

Uses of Computer Aided Instruction to allow students to practice rote skills, using drill and practice software, have led to small gains in student achievement in rote skills, especially for at risk students (Salerno, 1995). In his experimental study, “The Effect of Time on Computer-Assisted Instruction for At-Risk students,” Salerno investigated the use of Computer Aided Instruction for a group of 150 at risk fifth graders in an experimental setting (1995). During the study, students in the experimental group spent time working on Computer Aided Instruction, while students in the control group used workbooks to complete drill and practice (1995). Based on results from a district criterion referenced, Salerno concluded that computer use led to more time on task for students in practicing math skills and higher math achievement levels for at risk students (1995).

Some students using Computer Assisted Instruction may become less motivated to complete drill and practice in rote skills after using the program over several months or years (Brush, 1996). To counteract this loss of motivation which could lead to lower levels of achievement when using the software, Thomas Brush conducted a study of 65 fifth grade students using cooperative learning combined with Computer Aided Instruction over a period of 11 weeks (1996). Students who completed the computer based tasks in cooperative learning groups had higher levels of achievement as measured by standardized test performance and more positive attitudes as measured by anecdotal records of students’ comments while working with the software (1996). The study did not attempt to make a comparison to students who did not use the Computer Assisted Instruction to learn rote skills. Another study showed that students who were assigned to cooperative learning groups while interacting with Computer Aided Instruction systems had higher levels of math achievement than students who interacted with Computer Aided Instruction individually (Roschelle, Rafanan, Bhanot, Estrella, Penuel, Nussbaum, & Claro, 2010).

Friel describes the use of graphing software to help students learn data analysis and statistics (2008). While much of the research focuses on students in high schools and postsecondary students, Friel states that graphing software has the potential to allow students to focus on data analysis without getting mired in time consuming tasks such as completing complex calculations by hand or drawing a graph (2008). One potential drawback of using statistical software may be that students sometimes spend more time learning to use the software than in thinking about the patterns emerging from statistical analysis (Friel, 2008, p.294). According to Friel, much of the recent research on using statistical software with middle school and high school students has had inconclusive results or extremely limited generalizability due to the design of the studies and the measures of student learning regarding statistical analysis (2008). Friel calls for further research regarding the use of statistical software and other classroom technology by middle and high school students (2008).

Teaching Students Computer Programming

A second major use of classroom technology has been to teach students computer programming (Slavin, 2006; Tyler & Vasu, 1995). A recent project started at the University of Southern California seeks to increase student achievement in urban high schools with historically low achieving students by teaching them to program computer games (Tannenbaum, 2009). The effects of teaching students to write computer programs on academic achievement in other areas, such as math, have remained unclear over the past thirty years, however.

As early as the 1980s, Seymour Papert, called for teaching elementary students to write simple computer programs in the hopes that such programming would increase their academic achievement in math and other subjects (1993a, 1993b). According to Papert, allowing the students to learn programming in a computer language, such as the one he created called Logo, will allow them to take a more active role in their learning and master mathematical concepts better than they would in teacher directed classrooms where the curriculum is more scripted (1993a). In his work, *Mindstorms*, Papert states, "I see Logo as a means that *can, in principle,* be used by educators to *support the development* of new ways of thinking and learning" [italics original] (1993b, p. xiv).

Beginning in the mid-1980s, there has been a movement in American elementary schools to teach students Logo in the hopes that "active involvement in programming would result in increased cognitive development as well as increased problem-solving ability" (Tyler & Vasu, 1995, pp. 98-9). According to Tyler and Vasu, however, "This expected outcome … has not been found consistently in Logo research studies" (p. 99). Effects of teaching students programming have been restricted to increased achievement only in programming and "problem-solving skills that are most similar to those involved in the programming itself" (Slavin, 2006, p. 299).

Games and Simulations

A third common strategy for technology use in the classroom is to use computer games and simulations (Slavin, 2006). Throughout the twentieth century, educational reformers have called for more a more experiential basis to classroom activities (Dewey, 1938). Simulations have the potential to allow students to have virtual experiences with real world implications and engage in "authentic" problem solving (Shaffer, 2006; Wood, 1998). According to Shaffer, "Computer-based games expand the range of what players can realistically do – and thus the worlds they can inhabit and obstacles they can overcome" (p. 127). While simulation games like *SimCity* have been commercially available for several years, they often lack the authenticity to the considerations and concerns of real world professionals in a particular career (Shaffer, 2006). Shaffer calls these concerns the "epistemic frame," and calls for educators to use simulations that contain appropriate epistemic frames to allow students to engage in more genuine simulations that mirror the considerations and concerns of real world professionals (p. 160). According to Shaffer, educators can thus avoid simulated experiences that are so bound to the context of the simulation that they are "disconnected from the rest of experience … ." (Dewey, p. 48).

Unfortunately, the number of such "epistemic" games and simulations that are commercially available to educators is quite limited and their impact on students' achievement as measured by standardized tests has been insignificant (Shaffer, 2006). According to Shaffer, this lack of impact on student achievement is mainly due to the limitations of standardized tests to measure what he calls "innovative" learning (p. 4).

Other researchers, however, have found that instances of students connecting their experiences in computer simulations to real world experience were "rare" (Doerr & Pratt, 2008, p. 268). Further, students may need to develop specialized procedural knowledge that is specific to a given software tool to benefit from simulations (Hollebrands, Laborde, and Strasser, 2008). While this procedural knowledge may help the student successfully navigate the software and complete classroom activities, it may not be necessary to developing conceptual knowledge through traditional paper and pencil instruction and may thus represent an instructional approach that requires more time for students to build conceptual knowledge (Hollebrands, Laborde, and Strasser, 2008).

While educational computer games have the potential for motivating students who voluntarily spend free time playing video games, the design of many educational games have often been merely “extrapolations of drill and practice designs into a game format” (Slavin, 2006, p. 297). Research into the effects of computer games and simulations on student achievement has been limited (Slavin, 2006). A study of fourth and fifth graders in a five week summer math program showed that computer games resulted in more positive attitudes towards math among students, but no significant increase in math achievement (Fengfeng, 2008). A recent study of Italian primary grade students has shown some increases for students who played computer games for a period of three years on their math achievement as measured by a standardized math test (Bottino, Ferlino, Ott, & Travella, 2007). While the size of the sample in the study limits its generalizability, the findings do show some promise for the use of computer games and simulations with students. As early as the 1970’s, a study by the Educational Testing Service of a series of math games about fractions showed significant achievement gains for fourth, fifth, and sixth grade students (Dugdale, 2010).

Tutorial Programs

Another common historical use of computers that shows somewhat more promising results for content areas such as math is tutorial programs (Aleven, McLaren, Roll, & Koedinger, 2006; Slavin, 2006; Roll, Aleven, McLaren, & Koedinger, 2007). Tutorial programs have the advantage of allowing students to proceed at their own pace and repeat content and lessons as many times as needed (Slavin, 2006, p. 296). Based on Vygotsky’s learning theory which posits that students learn when they encounter problems that are slightly more complex than what they can solve without the guidance of a teacher, tutorials seek to constantly allow students to master the next higher concept or skill (Vygotsky, 1978). Computer tutorials, then, represent an application of Vygotsky's Zone of Proximal Development, in that "instruction is individualized and responsive to the student's ongoing performance" (Beal, Walles, Arroyo, & Woolf, 2007). The tutoring program is usually designed to provide scaffolding to students in the form of increasingly more specific advice and hints as they encounter difficulties in solving mathematical problems (Aleven, McLaren, Roll, & Koedinger, 2006). Some tutoring programs also seek to help students learn to monitor their own progress and strategies in mastering math content (Roll, Aleven, McLaren, & Koedinger, 2007). Such metacognitive learning could lead to higher achievement in math and other content areas beyond the scope of the content of the specific tutoring program, although results on such long term benefits have not been empirically verified yet (Roll, Aleven, McLaren, & Koedinger, 2007).

In a recent quasi-experimental study, Beal, Walles, Arroyo, and Woolf found that high school geometry students who participated in two 56 minute online tutoring sessions improved on a test of problem solving items taken from previously administered SAT math tests (2007, p. 46). Results were most significant for students who had the weakest math skills based on a pretest of similar items (p. 52). Significantly, the study represents the use of technology to supplement classroom instruction during two class periods of additional practice in solving geometry problems, rather than replace initial instruction in problem solving (p. 46).

Several experimental studies of tutoring software show strong, positive results for high school students. In an experimental study of 369 high school students, Morgan and Ritter found significantly positive effects for using a computerized tutoring program twice a week during math instruction (2002). Improvement was measured by students' scores on a state criterion referenced end of course assessment (2002). A study of 6,395 students in 10 high schools in Miami found significantly higher scores on a state achievement test for students who used tutoring software in an Algebra I curriculum (Ritter, Haverty, Koedinger, Hadley, & Corbett, 2008). Notably, positive differences in achievement test results were even more significant for special education and limited English proficiency students (Ritter, et al., 2008). A study of high school students in Washington state found significantly higher achievement scores for students using tutoring software (Ritter, et al., 2008). In a study of 126 high school students, Hannafin and Foshay found significantly higher scores on a high school graduation test for students who used computerized tutoring program four days per week during a math course for at risk students (2008). In a large study of ninth grade students in three urban high schools in Pittsburgh, Koedinger, Anderson, Hadley, and Mark found significantly higher test scores for students who used a computer based Algebra tutoring program (1997). The Pittsburgh study included several other factors, such as small group work and real world situations, so the effects on student achievement may not have been from the use of the software based tutoring system. According to one study, tutoring software is currently being used in over 2000 high school classrooms in the United States (Aleven, McLaren, Roll, & Koedinger, 2006). Studies that explore the impact of tutoring software on younger students' mathematics achievement are somewhat rare, however.

Not all studies of using technology for supplemental tutoring have produced positive results (Hollebrands, Laborde, and Strasser, 2008; Stephens, 2003; Hickey, Moore, and Pelligrino, 2001). In a study among Algebra students, Stephens found that using Microsoft Excel as a supplement for extra credit during the course did not result in higher achievement for students (2003). In a study of fifth grade students using a tutorial math educational software program, Hickey, Moore, and Pellegrino found that students' achievement in math problem-solving and interpretation increased, while their achievement in math computation actually decreased (2001). While the relationship between using online tutorial programs on student achievement merit further research, much use of these programs is limited to supplemental settings outside the regular classroom and beyond the regular school day.

Web 2.0 Tools

Recent innovations on Internet web sites, so called Web 2.0 tools, afford students further opportunities to take control of their learning and contribute to conversations about topics in the public domain. Recently developed Internet tools, such as wikis, blogs, and podcasts, “allow learners to link up, create, consume, and share independently produced information, media, and applications on a global scale” (Greenhow, Robelia, and Hughes, 2009, p. 249). This participatory culture of many web sites represents a constructivist means of learning as multiple users continually negotiate the relevance, validity and accuracy of information that is posted online. Conversations with peers via Web 2.0 tools can provide students with the “more capable peer” posited by Vygotsky to help them move to the next level of mastery of learning (1978).

The very best outcomes of such tools could include using these tools to create “a geographically distributed community of scholars studying a particular topic in education” (Dede, 2009, p. 261). In a recent study of online use by teens outside of the school setting, Cilesiz found that students used Web 2.0 tools to help create identities, research topics of interest, join a community of practice, and help shape future career goals (2009). The participants in Cilesiz’s study valued periods of free exploration on the Internet in an informal learning structure, because such sessions were “more aligned with their developing selves as self-directed learners and mature and autonomous individuals, contrasting them to the structure and authority in school, which they perceived to be limiting” (p. 262). Interestingly, the participants in the study did not always communicate online, and seemed to gain entry to a community of practice through interacting with other customers regularly at the Internet cafes

(Cilesiz, 2009). While the participants in Cilesiz's study seemed to benefit greatly from using Web 2.0 tools, some of the worst outcomes of Web 2.0 tools seem to be the numerous violent, profane, and misleading videos and verbal diatribes on sites such as *YouTube* and *MySpace*. Unfortunately, the very freedoms of most Web 2.0 tools to allow users to read and write information without editorial oversight lead most school systems to block their use within the formal, structured school setting.

In an effort to protect students' privacy and preserve their control over the curricular resources students use, most school districts continue to block many of the social networking sites that allow students to use Web 2.0 tools, in favor of a more traditional use of web sites as repositories of information that has been authoritatively verified by experts (Greenhow, Robelia, and Hughes, 2009, p. 247). While students use Web 2.0 tools outside of the school setting at an increasing rate (p. 247), the impact of such use will remain a challenging area for educational research, due to issues such as gaining access to students' postings and online conversations (p. 251).

Teacher-centered Uses of Classroom Technology

Interestingly, these more recent technology innovations represent less of a move toward constructivist, student centered classrooms, and more of an attempt to allow the classroom teacher to make their lesson presentations "more dynamic," by including multimedia and Internet resources (Slavin, 2006, p. 293). This use of multimedia shows promising early results on student achievement (*What Works in Teaching and Learning*, 2008; Chambers, Cheung, Gifford, Madden, & Slavin, 2004).

Educational Videos and Video Clips

As early as the 1960s, teachers and researchers started to explore the educational benefits of using educational video to deliver instruction to students. Video segments can combine various settings, music, demonstrations, and action in ways that a single teacher presenting instruction in front of a classroom of children cannot. Successful children's shows like *Sesame Street* have capitalized on the precept that "if you can hold the attention of children, you can educate them" (Gladwell, 2000, p. 100). Further, video segments can be viewed and reviewed by students multiple times as they gradually gain understanding of what they are viewing. Recent shows, such as *Blue's Clues* have capitalized on this recursive nature of video viewing by children (Gladwell, 2000). To adult observers, children often seem to lose interest and stop viewing videos to participate in a different activity, but may still be attending and gaining as much comprehension from the video as children who sit quietly and attend to the video (Anderson and Lorch, 1983). Most schools, however, have not relied on videos to deliver instruction in a for a major portion of instructional time in a systemic manner for school age children in the past fifty years, probably due to time constraints and the relative lack of significant evidence that viewing such videos leads to higher levels of student achievement.

More recent uses of educational videos have relied on shorter video clips the teacher shows to students interspersed between other activities, such as lectures and class discussions. A quasi-experimental study by Boster, Meyer, Roberto, Lindsey, Smith, Inge, and Strom found that students in grades six and eight who viewed short video clips from an online video clip collection called *United Streaming* during math class had higher scores on a criterion based math achievement test (2004). Teachers in the experimental group used video clips to reinforce the mathematical concepts they were presenting to the class during teacher centered instruction

(Boster, Meyer, Roberto, Lindsey, Smith, Inge, and Strom, 2004). Such a use of technology represents a move toward more dynamic, engaging teacher presentation of lessons, rather than a more student centered, constructivist approach.

Interactive Whiteboards and Student Response Systems

In light of the lack of research on the relationship between increasing the number of classroom computers on student achievement, many educational leaders have turned instead to investing technology resources on other forms of technology, forms such as interactive white boards and student response systems. A recent review of literature reveals a significant lack of research into the impact of these newer technologies on student achievement.

In one study, students who were visual learners and who were English Language Learners had higher achievement levels when exposed to multimedia math lessons using technology (*What Works in Teaching and Learning*, 2008). A University of Georgia study that is currently underway hopes to measure the impact of providing math teachers with more classroom computers, LCD projectors, networked printers and scanners, and extensive professional development in using technology (*What Works in Teaching and Learning*, 2005).

In a 2009 quasi-experimental study of 3338 students in 79 classrooms throughout the United States, Haystead and Marzano found a statistically significant gain in academic achievement in classrooms where the teacher used an interactive white board (2009). The study included students in elementary, middle, and high school classes at 50 different sites throughout the United States (p. 3). Public school and private school students from urban, suburban, and rural schools were included (p. 8). The highest achievement gains were among students in classrooms where the teacher had more than 10 years of teaching experience, had been using the interactive white board technology for at least 2 years, used the technology between 75 and 80%

of the time, and described herself as highly confident in using the technology (p. 36). It is worth noting that the achievement scores in the study were percentage scores based on teacher created pretest and posttest measures of self-selected units of study (p. 42). While the study suffers from several serious limitations, including its underwriting by a major manufacturer of interactive white boards, it does represent an initial attempt to scientifically determine whether or not the use of interactive white boards in the classroom leads to increased student achievement.

Theoretical Explanations of Classroom Technology Use

While classroom technology in the math classroom is not based on a single learning theory, several explanations have been used by the creators of learning technologies to develop their products. The following section attempts to outline some of the major learning theories common to classroom technology and link these theories to the relationship between technology usage and student learning in math.

Reinforcers

Starting with Pavlov's experiments with stimuli and responses, behavioral learning theorists have sought to explain children's learning through conditioning (Slavin, 2006, p. 136). B.F. Skinner expanded Pavlov's work to include investigations into the role of consequences on subsequent behavior (p. 138). According to behaviorist learning theory, if a student experiences a pleasurable consequence, or reinforcer, after a behavior, then the student is more likely to repeat the behavior (p. 139). As students willingly engage in the desired behavior more frequently, they may experience higher levels of learning (Wood, 1998, p. 280).

In an early use of technology in a learning environment, Skinner designed the first teaching machines to test the effects of reinforcers on lab animals' learning depending on different schedules of reinforcement (Wood, 1998, p. 4). Many modern computer aided instruction, especially drill and practice programs, include some sort of reinforcer, or reward, for students as they achieve stages of mastery through the program. Some of these rewards are in the form of achievement certificates that can be printed as a form of securing praise from the teacher or parents. Other programs use a visual representation of progress or mastery as students progress through learning the concepts presented (Aleven, McLaren, Roll, & Koedinger, 2006). For some students, merely using the computer is a reinforcer, regardless of the concepts or activities engaged in (Offer & Bos, 2009).

Games and simulations also often include rewards for students who perform well within the context of the game. While these rewards can be in the form of certificates, they sometimes take the form of new facets or levels of game play which are “unlocked” after the student achieves a certain level of mastery. Some theorists would argue that succeeding at finishing or “beating” the game serves as an intrinsic reward for many students engaged in learning through these types of technology tools. In “Why Video Games Matter,” Steve Borsch states, “Video games reward nearly every move a gamer makes with feedback” (2008, p. 18). According to Borsch, “what’s derailing many of our students may be simple: the lack of clear, short-term goals (per week, per day, per class, or even for portions of class time) with granular objectives, and the absence of immediate feedback and reinforcement” (p. 18). The use of reinforcers, or rewards within computer programs has been shown to increase student levels of motivation to continue participating in the learning activity (Scanlon, Buckingham, and Burn, 2005; Fitzpatrick, 2001), a finding which could lead to higher levels of student achievement resulting from an increase in the total time students spend engaged in learning. In the supplemental math software for the proposed study, students earn “blue ribbons,” as they complete each module and score a minimum passing score on the post module multiple choice quiz of 70% (*Study Island*, 2011).

This inclusion of a virtual recognition could be viewed as an attempt by the authors of the program to reinforce and motivate students as they use the program.

Some students may be reinforced by the availability of software based instruction and tutoring. Students using these programs do not have to wait for a teacher to finish helping other students and get to an individual needing assistance; software based instruction and tutoring offer explanations and hints immediately to students (Offer & Bos, 2009; Roschelle, et al., 2010). The immediacy of feedback which is a key component of many software tutoring programs may serve as a positive reinforcer for many students (Koedinger, Anderson, Hadley, & Mark, 1997; Offer & Bos, 2009). Further, students who make an error while using a computer based tutorial program are not subject to the negative reinforcers of having their error observed by other students in the classroom and the social embarrassment or ridicule that might accompany the error (Aleven, McLaren, Roll, & Koedinger, 2996; Koedinger, Anderson, Hadley, & Mark, 1997; Offer & Bos, 2009). This absence of ridicule may allow students to take more risks in using tutoring software than they would under more traditional classroom settings in front of a teacher and classmates (Koedinger, Anderson, Hadley, & Mark, 1997; Offer & Bos, 2009).

Assimilation and Accommodation

According to Jean Piaget, students learn through the processes of assimilation and accommodation (Piaget, 1950; Ormond, 2006). When a student encounters new information and can fit that information into existing structures of thought, or schemes, the student is using assimilation (Piaget, 1950, p. 8). If a student, however, encounters new information that does not fit with existing schemes, the student may have to revise or even create entirely new mental schemes to understand the information (p. 9). The fast pace of technological innovation forces many students and adults to accommodate new information and new ways of accessing and processing information. While many of today's students have grown up with technological tools such as the personal computer and the Internet, each year brings new ways of accessing information, organizing information, and communicating with other learners. As more students use technology outside the school setting, their ability to learn new information through assimilation and accommodation may become more developed, even in very young children who are just entering the school setting.

According to Piaget's stages of development, students gradually learn from the concrete objects immediate physical surroundings to abstract symbols which have no immediate, visible referents (Piaget, 1950). Jerome Bruner posited that in order to master math, students must transfer learning from situations involving concrete objects to symbolic language that represents various possible situations (1966, p. 20). This conceptual leap from describing concrete objects to using a symbol system to describe patterns and trends is often quite difficult for students (Kaput & Schorr, 2008). Kaput and Schorr point out the vast difference between children's work with concrete situations and objects as arithmetic and the use of an abstract symbol system to describe patterns and generate hypothetical situations as algebra (2008). According to Kaput and Schorr, "Until relatively late in the twentieth century, algebra was regarded as a specialist's tool," a tool not taught to the masses of students in middle and high school (p. 237). In making the transition from thinking in a concrete fashion to thinking in an abstract fashion, technology can offer students a virtual representation of the concrete as a scaffolding tool. Technology then, which offers students the ability to manipulate objects and graphical representations virtually, represents a possible bridge between the young child's world of concrete objects and the mathematicians world of abstract symbols (Dugdale, 2008; Laborde & Laborde, 2008). Friel states that technology has the capability to shift student's mental "activity to higher cognitive levels" (Friel, 2008, p.288).

Zone of Proximal Development

A Russian linguist, Lev Vygotsky, posited that students would learn best when faced with problems that were just beyond their ability to successfully solve independently (1978). According to the learning theory outlined by Vygotsky, a more adept expert, possibly a student's peer or an adult, could help the child succeed at the learning task within the child's zone of proximal development by providing support or scaffolding, thus leading to increased mastery and future success at tasks at the new level of learning (Slavin, 2006, p. 45).

According to Wood, "If children fail to master a task, not because their thinking is different in kind from that of adults, but simply because they lack the necessary experience and expertise, then it may be possible to help them to learn and understand situations which, left alone, they cannot master" (1998, p. 94). Wood argues that these situations require a tutor to guide a student and "provide a bridge between a learner's existing knowledge and skills and the demands of the new task," rather than a teacher to provide an already formed solution to the problem (p. 101). Using Computer Aided Instruction to help students achieve was based on Vygotsky's theoretical Zone of Proximal Development (Wood, 1998). According to Vygotsky's theory, students learn when they are working on a level just above the level they could perform alone (Slavin, 2006, p. 45).

In at least one study, the use of Computer Assisted Instruction led students to spontaneously ask a peer for help while learning new math content (Fitzpatrick, 2001). In another study, students who were cooperatively grouped with two other peers while interacting with Computer Aided Instruction had higher levels of math achievement than students who worked with Computer Aided Instruction individually (Roschelle, et al., 2010). This help seeking from someone the student perceived as more knowledgeable can be viewed as an example of Vygotsky and Bruner's theory of learning through guidance from someone more knowledgeable.

Some computer assisted instruction and tutorial programs seek to replace the expert peer or adult tutor with computer delivered assistance, or scaffolding, while a student is engaged in a task within their zone of proximal development (Wood, 1998; Offer & Bos, 2009). As much as fifty years ago, Jerome Bruner argued for the use of teaching machines, early versions of computer aided instruction, as a way of assisting the classroom teacher with giving more immediate feedback and further learning tasks to all students (Bruner, 1960). Bruner supported Skinner's early teaching machines as a way to, "take some of the load of teaching from the teacher's shoulders" (p. 84).

In computer assisted instruction, as the student gradually demonstrates mastery at solving problems at a given level, the computer program is designed to offer less and less guidance (Wood, 1998). The software program often offers more immediate feedback than a single teacher could in a room full of students, immediate feedback that can result in higher rates of achievement among students (Koedinger, Anderson, Hadley, & Mark, 1997). Extending the use of the theory, many programs use adaptive technology to constantly monitor a student's rate of success and then adjust the difficulty or pace of the learning tasks to increase the likelihood that students will be engaged in tasks within their zone of proximal development. It could be argued that tutorial programs seek to replace the guidance of a teacher with guidance from a computer program.

Constructivist Theory

Many initiatives to place technology in classrooms are seemingly based on the constructivist theory of learning. Placing technology in the classroom has the potential to change the manner in which students learn. Rather than relying on the teacher to deliver new information, demonstrate skills, and organize the learning segments, a computer can put the student more in charge of learning (Lopez-Morteo & Lopez, 2007).

According to Slavin, constructivists view students as active learners who create meaning through social interaction, discovery, and transformation of complex information (2006, p. 243). Working in a constructivist setting, students can encounter new information in their zone of proximal development relying on peers and technological applications like tutoring programs to succeed in tasks they could not complete independently (p. 244). By replacing the teacher as the sole source of new learning, classroom technology has the potential to allow students to work cooperatively to discover and create meaning from new information, while the teacher acts as the “guide on the side” (p. 243).

In the mathematics classroom, constructivist teaching “encourages students to build mathematical meanings that are more complex, abstract, and powerful than they currently possess, guiding and supporting students to construct personal meaning for the important mathematical ideas of our culture” (Battista, 2008, p. 136). Battista goes on to state that “constructivist instruction encourages students to invent, test, and refine their own ideas rather than unquestioningly follow procedures given to them by others” (p. 136). Linking constructivist theory to Piaget’s theory on learning, Battista states “Because constructivists see learning as resulting from accommodations students make to their current mental structures, constructivist teaching attempts to promote such accommodations by using carefully selected sequences of problematic tasks to provoke appropriate perturbations in students' thinking" (p. 136). Since a classroom teacher is limited in the amount of time and attention she can spend on any one student at a given time, technology holds the potential to allow students to individualize their own learning in ways not possible in a traditional classroom.

Drijvers and Trouche posit an "instrumental approach" to explaining how technology can help student learn mathematics (2008). According to Drijvers and Trouche, the teacher can be viewed as the conductor who leads students to use a variety of "instruments," consisting of technology tools and mental schemes, to solve certain mathematical situations (2008, pp. 366-368). The authors theorize that having a technology tool, or "artifact," available in the classroom may lead students to develop "mental schemes, which organize the problem-solving strategy, and induce the concepts that form the basis of the strategy" (2008, p.369). According to Drijvers and Trouche, a mental "scheme" consists of "the global solution strategy, the technical means that the artifact offers, and the mathematical concepts that underpin the strategy" (2008, p. 369). According to the authors, then, students should use a variety of technology tools in learning math, as the tools themselves may help shape students' learning and thinking about math (2008). The function of the teacher in helping students use technology is one of an orchestra conductor, a conductor who serves as "technical assistant, resource, catalyst and facilitator, explainer, task setter, counselor, collaborator, evaluator, planner and conductor, allocator of time, and manager (Drijvers & Trouche, 2008, p.380).

Essentially, the classroom computer has the potential to put the student in charge of his or her own environment, allowing him or her to make some choices about the content and pace of learning. The classroom teacher, then, must relegate some control of the pace and scope of learning while still maintaining management of the classroom and an overall direction for learning, a change that will require extensive changes in teacher education (Laborde & Laborde, 2008; Wilson, 2008). This shift in instructional focus changes the demands on the learner, who was traditionally challenged with "sitting, attending, listening carefully or diligently watching a performance by an adult, in relation to a task that the adult has set …" (Wood, 1998, p.81).

Many students engage in playing computer or video games outside of school, voluntarily spending hours learning how to play and succeed within the games. In addition to being in control of the game and getting constant feedback and reinforcement, computer games may appeal to children, because they have a limited, developing capacity to process unrelated information simultaneously and slower processing speeds than adults (Wood, 1998, p. 70). The games may offer a safer setting in which students are more willing to try different strategies to solve a problem and fail than in the typical middle school classroom. Further, students may be able to virtually interact with peers through games and simulations that are on a network or the Internet. This interaction with peers who may be playing at a level within the student's zone of proximal development may be highly motivational to students as they encounter new mathematics learning (Dugdale, 2008).

In describing observations of students and adults using software to create virtual geometrical figures, one summary of the development of geometry software characterizes users' control of the virtual environment as an invitation to "play" at mathematics (Goldenberg, Scher, & Feurzeig, 2008). According to the researchers, "Because the programs' design features invite exploration and play, users sense their own role in shaping and crafting their understanding of mathematics" (p. 79). While the summary did not report measures of achievement gains for students using the software, the researchers claim that, "What we all see as we watch children or adults 'play' with this software is often a change of perception of mathematics, from mathematics as a collection of rules and procedures to mathematics as an intellectual game, a response to curiosity, a human endeavor" (pp. 79-80).

Seymour Papert strongly advocates for the constructivist theory of learning in his work to allow students to program computers (2003b). According to Papert, allowing a student to program gives the student "a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building" (p. 5). Instead of being a passive recipient of new information and concepts, the child who creates computer programs controls the learning process and purpose (p. 21). In fact, Papert argues for a Piagetian curriculum, in which learning happens "without deliberate teaching" (p. 31). Papert argues that students will learn more when their curriculum is self-directed, rather than "disassociated" from their experience and interests (p. 47). Papert argues that the computer offers a context for learning and using mathematics in ways that are concrete and relevant to the child (p. 65). Piaget offers the suggestion of an instructional setting that is much less teacher directed; where teachers act more as expert guides offering suggestions and expertise to students to help them think through the current, student selected task at hand (p. 179).

In computer programming, according to Papert, the student encounters novel situations (2003b). The process of creating an increasingly refined set of instructions to get the computer to do what the student wants, such as moving a physical or virtual turtle or drawing a geometric figure, will allow the student to encounter some of the concepts of advanced math and assimilate the concepts into their current project (2003b). At times, in refining a program, a student will need to completely change the way he or she thinks of the task at hand, evidence, according to Papert, that the student is using accommodation to change the structure of thinking about information and the task (2003b). Papert envisions allowing students to program a physical or virtual turtle to draw as a transition to bridge the gap between concrete thinking and formal operational thinking requiring mastery of abstract concepts and processes (p. 187).

Papert further argues that gaining control over a computer through programming will help students overcome a cultural fear of math, or "mathophobia" (2003b, p.8). According to Papert, students are motivated to engage in tasks where they have control over the environment (2003b). This motivation and enjoyment of programming a computer to perform self-selected tasks will, in turn, allow students to develop a positive relationship with mathematical tasks and mathematical thinking (p. 47). Papert contrasts this positive view of mathematics with what he views as a cultural dislike and fear of math that is widespread (p. 8).

Web 2.0 tools have created the possibility for more student centered, constructivist classrooms. By putting students into the role of active participants in the process of analyzing and discussing knowledge, tools such as wikis and blogs have the potential to shift the focus of classroom instruction away from the teacher as the center of focus in a dramatic manner (Dede, 2009; Greenhow, Robelia, & Hughes, 2009). Web tools that allow students to author written works, audio works, and video works further have the potential to allow students the opportunity to have a real audience for their work, unconstrained by the bounds of a classroom located in a specific location at a specific time (Dede, 2009). The highly motivational aspects of Web 2.0 tools, such as being in control of their communications, having an audience, and almost instant feedback, may account for the increasing time students voluntarily spend with these tools outside of the classroom (Greenhow, Robelia, & Hughes, 2009). These tools also allow students to try on virtual identities (Greenhow, Robelia, & Hughes, 2009), a fulfilling of Bruner's call for students to assume the role and perspective of adult practitioners in a scholarly field (1966).

Seemingly the most significant effects of using technology to create a constructivist classroom would result from providing a computer for every student throughout the instructional period. Research showing positive effects of creating this one to one classroom computing environment, however, has been lacking (Dunleavy & Heinecke, 2007; Roschelle, et al., 2010). In a quasi-experimental study of 300 at risk middle school students over a two year period, Dunleavy and Heinecke found significant gains in science achievement, but no gains in math achievement based on scores from a state standardized achievement test (2007). In a study of high school students in Mexico, Lopez-Morteo and Lopez found that students who used instant messaging, chat rooms, and multi-player math games had higher levels of motivation to learn math (2007). The study did not attempt to measure the effects of participation in the one to one environment on math achievement. A study of fifth through seventh grade students in a one to one environment in Michigan found only moderately significant effects for math achievement (Ross, Lowther, Wilson-Relyea, Wang, & Morrison, 2003).

Somewhat more positive effects on math achievement were found by the authors of a one year laptop initiative in 195 Michigan schools, although much of the study focused on collecting observational data about how teachers and students used the laptop computers to participate in higher order thinking tasks, rather than the effects of laptop use on student achievement (Lowther, Strahl, Inan, & Bates, 2007). A four year study of 42 middle schools in Texas found significant increases in math achievement for students with laptops in two of three cohort groups (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2009). Significantly, both studies involved multiple classrooms in multiple schools using classroom technology in numerous subjects and for numerous purposes.

Computer games and simulations seem to present an ideal constructivist environment, since they allow students to direct virtual characters and see the results of their actions in a virtual environment. Jerome Bruner, a major proponent of constructivist theory, argued that learning was largely the process of allowing children to learn the underlying structures of knowledge through a spiraling series of encounters with realistic situations from the perspective of an adult scientist, mathematician, engineer, or other professional (1960). Bruner argued for using educational videos as a way of, "extending the student's range of experience,…helping him to understand the underlying structure of the material he is learning, and … dramatizing the significance of what he is learning" (p. 84).

Today, classroom technology allows students to virtually engage in learning activities that mirror the experience of adults in a myriad of professions (Shaffer, 2006). Bruner argued that learning was a process of "mastering techniques that are embodied in the culture and that are passed on in a contingent dialogue by agents of the culture" (Bruner, 1966, p. 21). According to Bruner's perspective, students can encounter the techniques that professionals use in learning as they engage in solving the challenges of their profession. Computer games and simulations represent one possible way for students to make these encounters virtually, while still in the classroom.

In his article, "From Content to Context: Videogames as Designed Experience," Kurt Squire proposes a new theoretical framework for educational researchers (2006). According to Squire, researchers should examine the ways students interact with games, to "account for players' actions in creating the experience" (p. 21). Squire argues that games allow students to learn by doing, participate in social worlds, and construct their knowledge of the concepts and skills inherent in the games (2006). While some learning of concepts occurs in games, Squire points out that much of the conceptual knowledge in game designs are either historically inaccurate or limited to use in the game environment (p. 21). Squire calls on game designers to create more engaging educational games and researchers to investigate the effects of gaming on student learning (p. 27). While gaming thus represents a potential area for further researcher, few schools have yet turned to widespread use of computer games and simulations to impact student achievement (Slavin, 2006). Such a move would necessitate a one to one computing environment for students for a significant portion of the day.

The challenges to implementing one to one computing environments for educational leaders often involve funding and facilities. While laptop computers are portable and can be carried from classroom to classroom by students, laptop batteries are still limited in charge time to fewer hours than the average school day. The need for additional electrical wiring and charging stations thus represents a significant hidden cost to educational leaders intending to implement one to one computing. To avoid the safety hazards associated with connecting laptop computers with wires to gain Internet access, schools have increasingly turned to wireless networks. The limitations of wireless g networking and the construction materials of most schools, relying heavily on concrete and steel, present costly obstacles to creating successful wireless school networks. Furthermore, wireless speeds have yet to match wired speeds in school applications. Finally, school leaders must struggle with the security issues inherent in providing students with costly laptop computers that can be moved from room to room, taken off campus, dropped, and easily stolen.

Teacher-centered or Student-centered

Many educational theorists have sought to make the classroom more student centered and experiential (Dewey, 1938; Wood, 1998). Drawing on the theories of Piaget and Bruner, David

Wood calls for more learning activities in which students solve “practical, concrete problems,” before encountering abstract thinking (p. 9). Allowing students to develop understanding by experiencing practical, concrete problems and then connecting that experience to more abstract procedural knowledge may lead to higher student achievement than just presenting students with abstract procedural knowledge according to a teacher defined schedule (Wood, 1998).

In addition to leading the balance of classroom activity toward more student centered instruction, technology has the potential to allow students to learn more conceptual mathematics knowledge by freeing them from the time consuming tasks of paper and pencil procedural knowledge (Tall, Smith, & Piez, 2008). While much of the research into the conceptual versus procedural knowledge potential of classroom technology has been limited to upper level mathematics courses and college or high school students, the early results of research with younger students shows that the use of computer simulation and modeling programs can lead students to focus more on conceptual knowledge (Doerr & Pratt, 2008).

In an interesting blend of teacher centered instruction and student centered instruction, a recent article in *Education Week* calls for classrooms that combine one to one computing with classroom projectors and interactive whiteboards (Manzo, 2009). According to the author, interactive white boards will allow students to collaborate as a group with students from other schools, communities, and countries (p. 24).

Critics of Educational Technology

Critics of educational technology argue that school systems have been duped into squandering precious financial resources on unproven educational innovations. After school systems have spent billions of dollars on hardware and software over the past thirty years, “in helping students learn traditional subjects, computers continue to play a minor role" (Slavin, 2006, p. 300).

As schools have increasingly turned to teaching higher order thinking skills in math, many have turned away from using computers to teach core subjects, instead relegating computer use to teaching programming, word processing, or enrichment (Slavin, 2006). Several studies have shown that classroom computers are actually turned off for the majority of the day and that computer use represents only a very small portion of academic learning time for students (Cuban, Kirkpatrick, & Peck, 2001; Ganesh & Berliner, 2004). After the failure of many drill and practice uses of technology to seriously impact student achievement in core subjects like math and reading, schools are increasingly realizing that technology is most effective when used to "enhance rather than replace teacher instruction" (Slavin, 2006, p. 293). A study of the effects of a significant effort to train and encourage teachers in 56 schools in Tennessee to integrate technology in uses beyond mere drill and practice, showed only mixed results in student achievement as measured by state standardized tests (Lowther, D., Strahl, J., Inan, F., & Ross, M., 2008). The lack of significant results on standardized tests led the study authors to question whether student performance on standardized tests might increase with increased meaningful technology use in the classroom over a longer period of time than the three year duration of the study (p. 23).

Even when technology use has led to higher achievement test scores, critics have been quick to point out that students using technology may not be learning the lessons schools intend. In a quasi-experimental study of 159 middle school students, Bickel and Cadle found that students who used math software for two 45 minute sessions for an average of eight weeks, had higher math achievement as measured by the Stanford 9 math problem-solving test (2003). The authors also found that students in the experimental group who used the software had higher scores on Stanford 9 tests of reading vocabulary, reading comprehension, language mechanics, and language expression (p. 29). According to the authors, then, the software actually improves students' test taking skills on standardized tests, rather than their math achievement (p. 30). The authors argue that, by diverting funds from other math innovations, the use of math software in this study actually resulted in superficial gains in test scores rather than actual increases in student achievement (p. 31). The authors conclude that technology actually hurt student achievement in this setting by diverting funding from more proven education initiatives (p. 4).

An alternate explanation for these study results could be that using the software actually led to gains in students' reading and language achievement. Since many standardized problem solving tests present items with words, rather than just mathematical symbols, students' reading abilities might significantly impact their performance on these test items. Whether using the software impacted students' test taking skills, math achievement, or both also belies the fact that students must perform well on standardized tests to graduate from high school in many states, gain entrance to colleges, and earn certifications in many professions. While not a major role of schools, helping students learn test taking skills may be a valid goal for educational leaders in preparing students for success beyond the classroom.

Despite spending time using Web 2.0 tools outside of the classroom, students may not be learning in ways that will benefit them in the academic world (Zhang, 2009; Luckin, Clark, Graber, Logan, Mee, & Oliver, 2009). Zhang points out that students often spend time viewing and creating media objects, such as music videos, rather than on sharing knowledge in Wikis or collaborating about academic topics on social networking sites (2009). Another major activity for students on Web 2.0 tools seems to be sharing opinions about media objects (Zhang, 2009).

Activities such as viewing music videos and chatting about which they like are far removed from the potential uses of Web 2.0 tools to collaborate in a sustained, structured way to further knowledge typical of the networking in academic professions (Zhang, 2009).

A recent descriptive study of 2611 adolescent British students' use of Web 2.0 tools revealed that most used the Internet to chat with friends through social networking sites and emails and actually avoided content that required extensive reading of text (Luckin, et al, 2009). While students did use collaborative tools, they often relied on Wikis and online collaboration to research topics and seek help on homework, and rarely sought to contribute to scholarly knowledge about a topic (p. 96). Most students in the study regarded social networking tools as "being used for socialization rather than learning" (p.97). Few students in the study used online tools to produce and publish content, such as podcasts and videos (p. 97).

Another criticism of using Web 2.0 tools in the classroom may come from current research into brain development. Recent brain research suggests that spending time on Web 2.0 tools outside of school may actually impair brain development (Small & Vorgan, 2008). According to Small and Vorgan, students who spend time on Web 2.0 tools may not have adequate learning experiences to allow them to form connections between their temporal and frontal lobes, connections that are vital to reasoning abilities and social skills (2008). Spending class time on allowing students to use Web 2.0 tools may also displace time spent on more traditional teaching strategies, strategies that may already be effective in raising student achievement. In light of the possibility that the increasing amounts of time students spend with Web 2.0 tools may change the way they develop cognitively, at least one educational researcher calls for further investigation into the matter (Owston, 2009).

Summary

Despite arguments against investing in technology, most public schools have made significant investments in technology (Becker, 2001; Anderson & Ronnkvist, 1999; Hayes & Greaves, 2008). While computer labs were popular in the early years of computers in schools, educational leaders have increasingly placed technology in the regular classroom in the hopes that it will lead to increased student achievement (Hayes & Greaves, 2008). Faced with differing levels of funding, Georgia school systems have made widely varied investments in classroom technology, especially over the past fourteen years. Educational leaders currently face a lack of abundant research into the effectiveness of newer classroom technologies on raising student achievement, technologies such as interactive white boards and student response systems. The proposed study represents one attempt to measure the relationship between introducing math tutorial software as one promising manifestation of technology integration in elementary school classrooms in Georgia on students' math achievement.

CHAPTER THREE: METHODS

Introduction

Although classroom computers have been implemented in public schools in a myriad of ways for the past thirty years, the vision of technology transforming teaching and learning has remained largely unfulfilled. When faced with limited resources, educational leaders have been hard pressed to find research-based proven models of technology integration that lead to increased student achievement. Faced with this lack of research, schools and school systems often invest in technology based on promises from technology vendors, rather than on research based implementation strategies.

This study attempted to investigate whether or not a statistically significant relationship exists between the use of *Study Island* supplemental math software and students' math achievement in a public elementary school in Georgia. Two primary research questions were used in this study. **RQ1:** Is the use of *Study Island*, a supplemental software program, correlated to students' mathematics achievement? **RQ2:** Is the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?

The researcher investigated the possible correlation between using *Study Island* during the course of an academic year and in a second implementation year, and student math achievement. While several studies examining the impact of using the software currently exist, most were conducted or funded by the publisher of the software. The study was unique in that it could become part of the research about this particular program that is not funded nor conducted by the publisher.

This chapter will include a brief description of the design of the study, the research questions and corresponding hypotheses, and a description of the participants and setting in the study. Next, a description of the instruments used and procedures for the study are provided. Finally, an explanation of the data analysis procedures used in the study are provided, including a brief discussion of the appropriateness of the procedure for the design of the study.

Design

This research was an ex post facto study. Ary, Jacobs, Razavieh, and Sorenson describe an ex post facto study as research that “is conducted after variation in the variable of interest has already been determined in the natural course of events” (2006, p. 356). The authors point out that the purpose of ex post facto research is to “investigate cause-and-effect relationships between independent and dependent variables,” but can be used in situations that “do not permit the randomization and manipulation of variables characteristic of experimental research” (p. 356). This study examined the relationship between two variables for third, fourth, and fifth grade public school students in Georgia during the 2011-2012, 2012-2013, and 2013-2014 school years: supplemental math software usage, the independent variable, and students’ math achievement, the dependent variable.

The first variable of interest in the study was the use of an online tutorial program called *Study Island* by students in the third, fourth, and fifth grade. According to the company’s website, the program is “a versatile Web-based standards mastery program built to each state’s standards” (Magnolia, 2009, p. 6). The program is intended to supplement the regular math curriculum, rather than replace all or some portion of it (Magnolia, 2009). The program’s makers claim that it provides a means to conduct diagnostic assessment, progress monitoring, and web-delivered instructional practice (Magnolia, 2009). In a typical elementary math lesson, students take a pretest online, and then are directed to short demonstrations and lessons, as well as brief games to reinforce specific areas of math instruction based on their pretest results (Magnolia, 2009). After completing the prescribed lessons, the student takes another test on the same math concepts and skills, and either progresses to the next level for another pretest, or returns to specific lessons based on the results (Magnolia, 2009). According to *Study Island*, the program provides motivation for students to remain engaged in math instruction, through the use of virtual achievement ribbons and performance reports to students, parents, and teachers (Magnolia, 2009). Finally, the makers of the program claim that it provides appropriate differentiation and remediation for students, because it prescribes online practice and games based on frequent diagnostic assessment and progress monitoring (Magnolia, 2010).

While an experimental or quasi-experimental approach would have assigned students to groups randomly and had students in the experimental group participate in online lessons using *Study Island* under tightly controlled conditions, the overarching need for equitable access to technology for all students in a Title I public school seemed to override the demands of a purely experimental study design. That is, the researcher decided that withholding access to the software program from some students could be viewed as unethical, given the growing digital divide between public school students from economically disadvantaged backgrounds and those from middle class and upper class socioeconomic backgrounds. For this reason, the study used data from a school that had already implemented the program for all students. The study compared data from two consecutive school years in which students used *Study Island* to the data from the school year prior to implementation of the software program.

The second variable of interest in this study was students' level of math achievement. The researcher operationally defined students' math achievement as the scaled score on the math portion of the Georgia Criterion Referenced Competency Test (CRCT). While using a state specific standardized test may limit the external validity of the proposed study, current No Child

Left Behind guidelines and Georgia state policy mandate that schools use results from this instrument to issue a school score to represent how well a school is doing, a score that is publicly reported. Because these public scores are important to school leaders to prevent their schools from facing state imposed sanctions, the use of the CRCT instrument may make study results more significant to this potential audience.

Research Questions

To investigate the relationship between the use of *Study Island* math software and the math achievement scores of third, fourth, and fifth grade students, the researcher proposed the following research questions.

RQ1: Is the use of *Study Island,* a supplemental software program, correlated to students' mathematics achievement?

RQ2: Is the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?

Hypotheses, Alternative Hypotheses, and Null Hypotheses

The first research question this study sought to address was (Research Question 1) Is the use of *Study Island,* a supplemental software program, correlated to students' mathematics achievement? The following sets of hypotheses were proposed to test research question one.

The corresponding research hypotheses are: (Hypothesis 1) Third grade students who use *Study Island* supplemental math software will have higher levels of math achievement than third grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Third grade students who use *Study Island* supplemental math software will have lower levels of math achievement than third grade students who do not use supplemental math software. The null hypothesis is: Third grade students who use *Study Island* supplemental math software will have the same levels of math achievement as third grade students who do not use supplemental math software.

Hypothesis 2 states: Fourth grade students who use *Study Island* supplemental math software will have higher levels of math achievement than fourth grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Fourth grade students who use *Study Island* supplemental math software will have lower levels of math achievement than fourth grade students who do not use supplemental math software. The null hypothesis is: Fourth grade students who use *Study Island* supplemental math software will have the same levels of math achievement as fourth grade students who do not use supplemental math software.

Hypothesis 3 is: Fifth grade students who use *Study Island* supplemental math software will have higher levels of math achievement than fifth grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Fifth grade students who use *Study Island* supplemental math software will have lower levels of math achievement than fifth grade students who do not use supplemental math software. The null hypothesis is: Fifth grade students who use *Study Island* supplemental math software will have the same levels of math achievement as fifth grade students who do not use supplemental math software.

The second research question this study sought to address was (Research Question 2) Is the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?

The research hypotheses for question 2 are: (Hypothesis 4) Third grade students who use *Study Island* supplemental math software in the second implementation year will have higher levels of math achievement than third grade students who do not use supplemental math software. The alternative hypothesis is: Third grade students who use *Study Island* supplemental math software in the second implementation year will have lower levels of math achievement than third grade students who do not use supplemental math software. The null hypothesis is: Third grade students who use *Study Island* supplemental math software in the second implementation year will have the same levels of math achievement as third grade students who do not use supplemental math software.

Hypothesis 5 states: Fourth grade students who use *Study Island* supplemental math software in the second implementation year will have higher levels of math achievement than fourth grade students who do not use supplemental math software. The alternative hypothesis is: Fourth grade students who use *Study Island* supplemental math software in the second implementation year will have lower levels of math achievement than fourth grade students who do not use supplemental math software. The null hypothesis is: Fourth grade students who use *Study Island* supplemental math software in the second implementation year will have the same levels of math achievement as fourth grade students who do not use supplemental math software.

Hypothesis 6 is: Fifth grade students who use *Study Island* supplemental math software in the second implementation year will have higher levels of math achievement than fifth grade students who do not use supplemental math software. The alternative hypothesis is: Fifth grade students who use *Study Island* supplemental math software in the second implementation year will have lower levels of math achievement than fifth grade students who do not use supplemental math software. The null hypothesis is: Fifth grade students who use *Study Island* supplemental math software in the second implementation year will have the same levels of math achievement as fifth grade students who do not use supplemental math software.

Participants and Setting

Subjects for the study were third, fourth, and fifth grade students in a public elementary school in Georgia. The research was conducted after the implementation of *Study Island* supplemental math software and in a school to which the researcher had access; therefore, the sample represented a convenience sample.

According to the Georgia Department of Education, during the 2011-2012 school year, 1,634,251 students were enrolled in grades K-12 (2011). By ethnicity, 44% of students were white, 37% black, 12% Hispanic, 3% Asian, and 3% multiracial (Georgia Department of Education, 2011). Statewide, 57% of students were eligible to receive free/reduced lunch, and thus members of the economically disadvantaged subgroup (Georgia Department of Education, 2010). By educational setting, 10.3% of Georgia students were served as students with disabilities, 6% were Limited English Proficient, 17.7% were enrolled in an Early Intervention program (grades K-5), 10.3% were Gifted, and 2.1% were served in Alternative Education settings (Georgia Department of Education, 2011). While demographic percentages were not available for students just in grades 3-5 statewide, an assumption will be made, because of the size of the study sample, that the demographics of the students in the selected grades are statistically similar to the demographics of all students in grades K-12.

The school in the study sample was a Title I elementary school located in a rural area of Georgia. According to information in the school's reports on the Georgia Department of Education's website and the school's website, the school served approximately 442 students in grades Pre-K through fifth grade during the 2010-2011 school year. Approximately 74 students were in third grade, 68 were in fourth grade, and 91 students were in fifth during the 2011-2012 school year, although not all of those students were at the school for the full academic year.

Demographic data taken from the school Report Card on the Georgia Department of Education website for the 2010-2011 school year revealed the following demographics. By ethnicity, approximately 86% of the students in the school were white, 2% were black, and 7% were Hispanic. Approximately 63% of students were eligible for free and reduced meals, making up the economically disadvantaged subgroup. By educational setting, 13% of students were served as students with disabilities, 4% as limited English proficient students, 22.9% were in enrolled in the early intervention program, and 12.9% in the gifted program.

The school selected for this study was a Title I elementary school serving Pre-K through fifth grade students in a rural area of Georgia. This school is part of a small school district with 10 elementary schools and approximately 10,000 students. An interview with the school's academic coach revealed that students in the school come from suburban and rural areas, with the majority living in older, single family homes and trailers (L. Welborn, personal communication, Sep. 23, 2013).

Instrumentation

The researcher measured the usage of *Study Island* math software and students' math achievement scores for the 2011-2012, 2012-2013, and 2013-2014 school years. The instruments used in those measurements are discussed below.

To measure *Study Island* software usage, data was collected from the *Study Island* math software database for the 2012-2013 and the 2013-2014 school years. The software recorded minutes spent during online sessions for students throughout the instructional year. The software also contained a timeout feature that stopped a lesson if a student stopped interacting with the software for a few minutes (*Study Island*, 2011). The program also generated teacher reports detailing each student's time spent in each module and accuracy on the post-module multiple choice quiz, so that the teacher could monitor and adjust students' use of the program (*Study Island*). An interview with the school's academic coach revealed that the teacher assigned to monitor students in the computer lab regularly redirected students who seemed off task, either by anecdotal observation or by examining the reports of the amount of time each student spent on the tasks within the software (L. Welborn, personal communication, Sep. 23, 2013). As a result of these features of the program, the researcher assumed that the reported times of student software usage were a reliable measure for the purposes of the study.

The researcher also assumed that the formative assessments contained in the software program were both reliable and valid measures of successful completion of each module. A 70% average accuracy rate was the default threshold for students to complete each *Study Island* module successfully (B. Miller, personal communication, July 25, 2012). While no third-party, objective data existed for the reliability and validity of these assessments, the proposed study used a state standardized test with appropriate reliability and validity evidence to attempt to measure the relationship between successfully completing the software modules and math achievement. It could be argued that this study could help provide validity for the software's measures of student mastery because the software's measures were compared to an external measure of math achievement that is both valid and reliable – the Georgia CRCT.

Another limitation lies in the frequency that math teachers, the school's academic coach, and the computer lab teacher reviewed the progress data within the program. Because the teachers and academic coach tended to review students' progress data only every few weeks, often at the end of a midterm (four and one half weeks) or grading period (nine weeks), students may not have received as much individualized help or tutoring as possible (L. Welborn, personal communication, Sep. 23, 2013). That is, a student who started to struggle with a particular module or unit of study in math class may not have received immediate opportunities to work on the concepts from that unit in the software program, since the program relies on the computer lab teacher or math teacher to assign units of study before requiring students to take a diagnostic pretest on a set of modules.

The researcher also assumed that each student included in the study actually used his or her own login credentials to access and use the software. Similarly, the students included in the sample, who are reported to have used the software during the 2012-2013 and the 2013-2014 school years, were assumed to be the same students who took the math achievement tests.

The operational definition of the use of supplemental math software will be the use by a student of the online program, *Study Island*, during the school year before the administration of state standardized testing. According to Buffy Miller, an implementation specialist with *Study Island*, the program is designed to supplement regular classroom instruction in math (B. Miller, personal communication, July 25, 2012). In the school in the proposed study, students worked on the program during a weekly computer lab time, in the math classroom after completing lessons, and at home via a web-based interface (L. Welborn, personal communication, Sep. 23, 2013). Since students attended computer lab sessions each week for approximately 40 minutes over the course of approximately 31 weeks before taking the CRCT test each year, the researcher concluded that students had at least 20 hours during the course of the school year to use the software program, even if they did not choose to use the program in the math classroom or from home (L. Welborn, personal communication, Sep. 23, 2013). Because students had the option to use the program to work on only two subjects, math or reading, the researcher concluded that students had ample time to complete modules over the course of the school year. According to the *Study Island* software instructions for schools implementing the program, students using the program are to complete modules assigned by the teacher (*Study Island*, 2011). In each module, students take a pretest, view a short segment of instructional review in a math concept including vocabulary and algorithms to solve math expressions, then take a short, multiple choice quiz to ensure their mastery of the module before moving on to the next assigned module (*Study Island*, 2011). The teacher receives reports on each student's progress each week to monitor their use of the program (*Study Island*, 2011).

An interview with the school's academic coach revealed that students used the program frequently during their weekly computer lab time during the 2012-2013 school year (L. Welborn, personal communication, April 8, 2014). For both school years in the proposed study, the coach revealed that students were assigned one to two 40 minute sessions in the computer lab each week, during which they often used the software (L. Welborn, personal communication, April 8, 2014). Students who were identified as at- risk in math also completed modules during a weekly extra session in the lab and during times in their regular math classrooms (L. Welborn, personal communication, Sep. 23, 2013). Math teachers reviewed benchmark data from the school's benchmark math tests, as well as weekly formative data, to continue to identify at-risk math students approximately once each nine weeks (L. Welborn, personal communication, Sep. 23, 2013). A review of reports showing the time each student spent working in the software and the modules completed by each student confirmed this conclusion for the students who will be included in the experimental group for the study. Finally, an interview with the school's academic coach revealed that the math teachers in the school reviewed reports from the software program as a group each grading period to consider adjusting instruction and program use for individual students and small groups of students (L. Welborn, personal communication, Sep. 23, 2013).

Students' math achievement was operationally defined as students' scores on the math portion of the Georgia Criterion Referenced Competency Test. The instrument reported student scores as percent correct, scaled scores, and whether students did not meet, met, or exceeded state performance standards (Georgia Department of Education, 2008b). According to the Georgia Department of Education, reliability estimates for the CRCT test in math range from .87 to .91 (2004). The Department of Education stated that it ensures validity by having "qualified, professional content specialists" write items, and periodically submitting items for review by curriculum specialists and Georgia educators (2004). Further, the department submits the test instrument quarterly to the Georgia Technical Advisory Committee, a group of "experts in the field of educational measurement who review all aspects of the test development and implementation process on a continual basis" (p. 10).

According to the Georgia Department of Education, comparing scores on the CRCT within the same content area and grade level is appropriate (Georgia Department of Education, 2008b). Thus, valid comparisons in the proposed study were made between students using the same content area (math) and grade levels of the instrument.

Ary, Jacobs, Razavieh, and Sorensen point out that assessing the reliability of criterion-referenced tests is more difficult than for norm-referenced tests (2006, p. 272). Because of budget limitations, most Georgia students did not take national, norm-referenced tests on a regular basis in elementary school grades. Furthermore, the findings from the proposed study may be limited because schools in other states do not use the Georgia Criterion Referenced Competency Test to assess student achievement.

Despite its limitations, the CRCT was the instrument the Georgia Department of Education used to assess whether or not schools made adequate yearly progress on the state of

Georgia College and Career Ready Performance Index as mandated by the federal No Child Left Behind law. Using CRCT results that show how many students did not meet, met, and exceeded standards, The Department of Education gave each school a performance score that was based on how many of the school's students did not meet, met, or exceeded standards and whether the school's percentage of students meeting or exceeding standards increased. As such, the number of students who did not meet, met, or exceeded standards represented a highly significant operational definition of student achievement for educational leaders as they strived to avoid state imposed sanctions for their schools and systems. The researcher hoped that using CRCT math test results as the operational definition for students' math achievement will thus make the proposed study more significant and useful for current educational leaders.

The researcher has presented a list of technology terms below for the convenience of readers. While many of the terms are fairly new, and still evolving in meaning, the researcher has attempted to provide the definition intended for the purposes of this proposed study. The list is presented in alphabetical order with accompanying citations.

A blog is an online diary or web log "containing the writer's or group of writers' own experiences, observations, opinions, etc." (Dictionary.com, n.d.).

Computer assisted instruction, or CAI, is "a program of instructional material presented by means of a computer or computer systems" (Brittanica.com, n.d.). Computer assisted instruction is sometimes referred to as computer aided instruction or computer assisted learning. The program used to deliver instruction is sometimes referred to as an Integrated Learning System.

A computer game is a game played on a computer or computer network, "by manipulating a mouse, joystick, or the keys on the keyboard of a computer in response to the graphics on the screen" (Collins English Dictionary, n.d.).

Computer programming is the process of "creating a sequence of instructions to enable the computer to do something" (WordNet 3.0, n.d.).

A computer simulation is a computer program that uses "the technique of representing the real world by a computer program" (Thefreedictionary.com, n.d.). Students might use a computer simulation to investigate possible effects of manipulating one or more variables in a hypothetical situation that is based on reality.

An interactive whiteboard is a large "touchpad connected to a computer" designed so that a classroom full of students can see it at once (Williams, M., n.d.).

A podcast is "a digital audio or video file or recording, usually part of a themed series, that can be downloaded from a Web site to a media player or computer" (Dictionary.com, n.d.).

A social networking site is a web site that "enables users to create public profiles … and form relationships with other users," (webopedia.com, n.d.). These sites "can be used to describe community-based Web site, online discussions forums, chatrooms and other social spaces online" (webopedia.com, n.d.).

Software refers to "the programs used to direct the operation of a computer" (Dictionary.com, n.d.). Software is the written set of computer language or code that guides the computer's operating system on how to do something. Software is often loaded to a computer from an Internet download or by downloading it from computer discs.

A student response system is a set of hardware with a handheld device for each student linked to a computer that serves as a polling station to record and tally responses that "enables each student to participate by responding to questions during the learning process" (Horowitz, n.d.).

The term Web 2.0 refers to newer web sites and applications on the World Wide Web which are designed to "focus on user collaboration, sharing of user-generated content, and social networking" (Collins English Dictionary, n.d.).

A wiki is a "web site that allows anyone to add, delete, or revise content," (Dictionary.com, n.d.).

Procedures

The researcher obtained permission from the school district's superintendent and Liberty University's Institutional Review Board to conduct the study. Data were collected in compliance with school district policies.

The researcher obtained an anonymized list of all third, fourth, and fifth grade students who were present for the full 2011-2012 academic year as defined for determining inclusion in calculating a school's College and Career Ready Performance Index score under current Georgia procedures to comprise three control groups, one per grade level. All identifying data for individual students was stripped from the data set and replaced with a random number by a school district employee before the researcher obtained the list. Further, the students in each data set were reorganized in ascending order based on random numbers. Only students present for the full academic year were included in the data set obtained from the district. Under current Georgia practices, to be considered present for the full academic year, and therefore have achievement scores count within a school's performance index, the student must have been continuously enrolled for at least 65% of the days from the beginning of the school year through the testing window (Georgia Department of Education, 2013). The list of 2011-2012 third, fourth, and fifth graders comprised three control groups, separated by grade level.

Next, an anonymized list of third, fourth, and fifth grade students who were considered present for the full academic year by the same criteria for the full 2012-2013 academic year was obtained. These students comprised three experimental groups, separated by grade level.

Finally, an anonymized list of third, fourth, and fifth grade students who were considered present for the full academic year under current state guidelines for the 2013-2014 school years were included in a second set of three experimental groups, again separated by grade level. This list comprised a second set of experimental groups that were compared to the 2011-2012 control group.

CRCT scores for each student in each group were obtained and organized in tables. Data from the experimental and control groups were kept in separate tables. Students from the control groups (2011-2012 school year) and students from the treatments groups (2012-2013 and 2013-2014 school years) were assigned a random number using *SPSS Student Version 15.0* software, so that confidentiality could be maintained. For data analysis purposes, the control group and experimental group for each grade level were considered independent groups, rather than paired, because they contained different students who completed the same math curriculum in subsequent years. Throughout the statistical analysis and reporting phases of the proposed study, only these randomly assigned numbers were used to identify student scores. All data sets were maintained in a locked file cabinet at the school under administrative supervision, as required by the local school district. Additionally, any electronic version of the data was kept only on the hard drive of a password secured laptop computer used by the researcher. Access to the paper and electronic versions of the data was available only to the researcher and school administrators at the school and district selected for the study. At the conclusion of the study, all electronic and paper copies of the data were held on file in a locked vault at the school and will be kept for three years, and then destroyed.

The researcher obtained anonymized data from the *Study Island* database regarding student use of the program during the 2012-2013 and 2013-2014 school years. An employee of the school district stripped the data of student names and other identifying information and replaced it with random numbers, and then reorganized the data in ascending order based random number before releasing the data to the researcher. This data was used to measure the degree of implementation of the program among students who had the opportunity to use the supplemental program during the school year. The data was also used to reveal trends in how often various subgroups of students use the program. For instance, the researcher analyzed whether students with disabilities used the program more than other students because the software allowed each student to work at his or her present level of performance. It could be argued that a number of variables, such as student attendance, schedule disruptions, and student off task behavior, could affect the fidelity of implementation for any software program. Interviews with the computer lab teachers, math teachers, and academic coach regarding the use of the software during the 2012-2013 and 2013-2014 school years were also conducted and analyzed in an attempt to describe the fidelity of implementation of the software. Because the study attempted to investigate the possible correlation of achievement scores for students who actually used the software, the data showing student use was key to analyzing the data between software use and math achievement scores.

Data Analysis

The first research question this study sought to address was (Research Question 1) **"**Is the use of *Study Island,* a supplemental software program, correlated to students' mathematics achievement?”. To investigate the research question, three comparisons were made. The CRCT Math scaled scores of 2011-2012 third graders (pre *Study Island* implementation) were compared to the CRCT Math scaled scores of 2012-2013 third graders (post *Study Island* implementation); the CRCT Math scaled scores of 2011-2012 fourth graders (pre *Study Island* implementation) were compared to the CRCT Math scaled scores of 2012-2013 fourth graders (post *Study Island* implementation); and the CRCT Math scaled scores of 2011-2012 fifth graders (pre *Study Island* implementation) were compared to the CRCT Math scaled scores of 2012-2013 fifth graders (post *Study Island* implementation).

The second research question this study sought to address was (Research Question 2) **“**Is the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?”. To investigate the research question, three comparisons were made. The CRCT Math scaled scores of 2011-2012 third graders (pre *Study Island* implementation) were compared to the CRCT Math scaled scores of 2013-2014 third graders (post *Study Island* implementation year two); the CRCT Math scaled scores of 2011-2012 fourth graders (pre *Study Island* implementation) were compared to the CRCT Math scaled scores of 2013-2014 fourth graders (post *Study Island* implementation year two); and the CRCT Math scaled scores of 2011-2012 fifth graders (pre *Study Island* implementation) were compared to the CRCT Math scaled scores of 2013-2014 fifth graders (post *Study Island* implementation year two).

For each of the six comparisons, the researcher developed null hypotheses. The null hypotheses stated that there would be no statistically significant difference between the CRCT Math scaled scores of third, fourth, and fifth graders from the 2011-2012 school year (pre Study Island implementation) and the CRCT Math scaled scores of third, fourth, and fifth graders from the 2012-2013 (first year of Study Island implementation) and 2013-2014 (post Study Island implementation year two) school years. The researcher conducted independent samples *t*-tests to test each of the null hypotheses. Independent samples *t*-tests are used to test differences between two means of two different groups (Salkind, 2008). For each of the six independent samples t-tests, the researcher determined that the null would be rejected if the alpha level was less than .05.

The results of the six independent samples t-tests and their bearings on the research questions are presented in Chapter Four. Based on results from statistical analyses and descriptive information from teacher interviews regarding the implementation of the software, the research provided tentative conclusions regarding the relationship between computer-based tutorial program usage and student math achievement in Chapter Five.

CHAPTER FOUR: FINDINGS

Introduction

The purpose of this study was to investigate the relationship between the use of *Study Island* supplemental math software and students' math achievement in a Title I public elementary school in Georgia during the 2011-2012, 2012-2013, and the 2013-2014 school years. Data from the school was collected regarding the use of a supplemental math software program called *Study Island* during the 2012-2013 and the 2013-2014 school years. Data on students' math achievement was collected from school level reports for the year prior to Study Island implementation, 2011-2012, and from the two school years in which the software was used, 2012-2013 and 2013-2014. The data consisted of anonymized software usage data for individual students and scaled scores from the math portion of the CRCT test. The data also included subgroup information, showing whether students were included in the economically disadvantaged subgroup and/or the students with disabilities subgroup. Descriptive data regarding students' use of the supplemental software during the 2012-2013 and 2013-2014 school years is provided. Student's math achievement data was examined using a two-tailed *t* test for independent samples. Chapter four consists of three sections, including demographic data of the participants, the results, and the summary.

Research Questions

This study sought to address the following two research questions:

1. Is the use of *Study Island*, a supplemental software program, correlated to students' mathematics achievement?
2. Is the use of *Study Island*, a supplemental software program, during two consecutive school years correlated to students' mathematics achievement?

In order to investigate the research questions, the researcher proposed three hypotheses with each of the questions.

Hypotheses, Alternative Hypotheses, and Null Hypotheses

In order to make the results of this study quantifiable, the researcher proposed hypotheses with each of the research questions. For each hypothesis, the researcher also created a null hypothesis and alternative hypothesis.

The first research question asked whether the use of the supplemental math software program *Study Island* affected students' mathematics achievement. The researcher collected data from sets of third grade students. The corresponding research hypotheses are: (Hypothesis 1) Third grade students who use *Study Island* supplemental math software will have higher levels of math achievement than third grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Third grade students who use *Study Island* supplemental math software will have lower levels of math achievement than third grade students who do not use supplemental math software. The null hypothesis is: Third grade students who use *Study Island* supplemental math software will have the same levels of math achievement as third grade students who do not use supplemental math software.

To further address the first research question, the researcher also gathered data on fourth grade students. The following hypotheses were proposed. Hypothesis 2 states: Fourth grade students who use *Study Island* supplemental math software will have higher levels of math achievement than fourth grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Fourth grade students who use *Study Island* supplemental math software will have lower levels of math achievement than fourth grade students who do not use supplemental math software. The null hypothesis is: Fourth grade students who use *Study Island* supplemental math software will have the same levels of math achievement as fourth grade students who do not use supplemental math software.

The researcher also studied results from fifth grade students and made the following hypotheses. Hypothesis 3 is: Fifth grade students who use *Study Island* supplemental math software will have higher levels of math achievement than fifth grade students who do not use supplemental math software. The alternative hypothesis for question 1 is: Fifth grade students who use *Study Island* supplemental math software will have lower levels of math achievement than fifth grade students who do not use supplemental math software. The null hypothesis is: Fifth grade students who use *Study Island* supplemental math software will have the same levels of math achievement as fifth grade students who do not use supplemental math software.

The second research question asked whether using the supplemental software program *Study Island* during two consecutive school years correlated to students' mathematics achievement. Data was collected from sets of third, fourth and fifth grade students from the 2011-2012 school year (before software implementation) and the 2013-2014 school year (after software implementation.

The research hypothesized that (Hypothesis 4) Third grade students who use *Study Island* supplemental math software for two consecutive years will have higher levels of math achievement than third grade students who do not use supplemental math software. The alternative hypothesis is: Third grade students who use *Study Island* supplemental math software for two consecutive years will have lower levels of math achievement than third grade students who do not use supplemental math software. The null hypothesis is: Third grade students who use *Study Island* supplemental math software for two consecutive years will have the same levels of math achievement as third grade students who do not use supplemental math software.

Hypothesis 5 states: Fourth grade students who use *Study Island* supplemental math software for two consecutive years will have higher levels of math achievement than fourth grade students who do not use supplemental math software. The alternative hypothesis is: Fourth grade students who use *Study Island* supplemental math software for two consecutive years will have lower levels of math achievement than fourth grade students who do not use supplemental math software. The null hypothesis is: Fourth grade students who use *Study Island* supplemental math software for two consecutive years will have the same levels of math achievement as fourth grade students who do not use supplemental math software.

Hypothesis 6 is: Fifth grade students who use *Study Island* supplemental math software for two consecutive years will have higher levels of math achievement than fifth grade students who do not use supplemental math software. The alternative hypothesis is: Fifth grade students who use *Study Island* supplemental math software for two consecutive years will have lower levels of math achievement than fifth grade students who do not use supplemental math software. The null hypothesis is: Fifth grade students who use *Study Island* supplemental math software for two consecutive years will have the same levels of math achievement as fifth grade students who do not use supplemental math software.

Descriptive Statistics

The researcher collected data over a three year period from third, fourth, and fifth grade students who were enrolled in a Title I public elementary school in northwest Georgia. Data from students who were not present for at least 65% of the school year, including the state testing window, were excluded from the study. Students in the control group during the 2011-2012 school year consisted of 76 third graders, 74 fourth graders, and 71 fifth graders. During the first year of software implementation, 2012-2013, participants included 54 third graders, 76 fourth graders, and 74 fifth graders. During the second year of software implementation, 2013-2014, participants included 58 third graders, 63 fourth graders, and 69 fifth graders.

In the control group, 57 of the 76 third graders were members of the economically disadvantaged subgroup, while 51 of 74 fourth graders and 47 of 71 fifth graders were members. The students with disabilities subgroup included 14 third graders, 12 fourth graders, and 6 fifth graders. During the first year of software implementation, 2012-2013, the economically disadvantaged subgroup included 45 of 54 third graders, 59 of 76 fourth graders, and 53 of 74 fifth graders. The students with disabilities subgroup during the first year of software implementation included 11 third graders, 10 fourth graders, and 12 fifth graders. During the second year of software implementation, 2013-2014, the economically disadvantaged subgroup consisted of 44 of 58 third graders, 52 of 63 fourth graders, and 54 of 69 fifth graders. The students with disabilities subgroup consisted of 13 third graders, 12 fourth graders, and 4 fifth graders. This demographic data is displayed in Table 1.

Table 1

Demographic Data for 2011-2012, 2012-2013, and 2013-2014

	School Year								
	2011-2012			2012-2013			2013-2014		
Group	*n*	*ED*	*SWD*	*n*	*ED*	*SWD*	*n*	*ED*	*SWD*
3rd Graders	76	57	14	54	45	11	58	44	13
4th Graders	74	51	12	76	59	10	63	52	12
5th Graders	71	47	6	74	53	12	69	54	4

n = total number included in sample

ED = number of economically disadvantaged students

SWD = number of students with disabilities

One of the key assumptions in this study was that students actually used the supplemental math software in consistent and meaningful ways over the course of an academic year. Reports from the software program were used to test this assumption. During the first year of implementation, 2012-2013, interviews with the school's academic coach revealed that students had the opportunity to use the software during a weekly 40 minute regularly scheduled class in the computer lab (L. Welborn, personal communication, May 30, 2014). Students interacted with the software as a whole class under the direction of a state certified elementary teacher using an interactive white board, and individually at computer workstations with headphones (L. Welborn, personal communication, May 30, 2014). Students started using the program within the first month of school and continued using it through the state testing window in early May (L. Welborn, personal communication, May 30, 2014). In all, students had approximately 29 weekly sessions of forty minutes each to use the software, or a potential of 1160 minutes of use. Other weeks were spent taking benchmark tests or completing online surveys in the computer lab (L. Welborn, personal communication, May 30, 2014).

According to the academic coach, a certified computer lab teacher collaborated with the grade level math teachers throughout the two years of implementation regarding which modules to assign in the program (L. Welborn, personal communication, Oct. 21, 2015). The academic coach also revealed that the computer lab teacher monitored students while they used the program to ensure they were on task and not simply clicking their way through the questions randomly in an attempt to get to the game segments of each module (L. Welborn, personal communication, Oct. 21, 2015). Based on this monitoring and reports from the software program about the accuracy of each student's responses, the computer lab teacher worked with students in small groups and one on one as needed to reteach concepts they were struggling with and to encourage them to slow down and engage with the software in a thoughtful, meaningful manner (L. Welborn, personal communication, Oct. 21, 2015).

An analysis of usage reports for the 2012-2013 school year revealed that third grade students used the program for an average of 369 minutes each. Third graders in the economically disadvantaged subgroup spent an average of 348 minutes using the program. Third graders in the students with disabilities subgroup averaged 352 minutes of usage. Fourth grade students spent an average of 413 minutes using the program. Fourth graders in the economically disadvantaged subgroup spent an average of 404 minutes using the program. Fourth graders in the students with disabilities subgroup spend an average of 415 minutes using the software. Fifth grade students spent an average of 370 minutes using the software. Fifth grade students in the economically disadvantaged subgroup spent 364 minutes on overage, and students in the students with disabilities subgroup spent 338 minutes on average using the software.

During the 2013-2014 school year, students again had the opportunity to use the software once per week during a regularly scheduled 40 minute computer lab class under the direction of a state certified elementary teacher (L. Welborn, personal communication, May 30, 2014). Students used the program during whole class sessions with the projector and interactive white board, and individually at computer stations with headphones (L. Welborn, personal communication, May 30, 2014). Students began using the software in the third week of school and continued using it through the state testing window in late April (L. Welborn, personal communication, May 30, 2014). Students had the opportunity to use the software during a total of 27 weekly sessions of 40 minutes each, or 1080 potential minutes. The remaining weekly sessions in the lab were spent taking benchmark tests and completing online surveys (L. Welborn, personal communication, May 30, 2014). The computer lab teacher again collaborated with grade level math teachers regarding assigned modules, and monitored students while they used the software to encourage them to engage with the software in a purposeful manner (L. Welborn, personal communication, Oct. 21, 2015).

An analysis of software usage reports for the 2013-2014 school year revealed that third grade students used the program for an average of 707 minutes each. Third graders in the economically disadvantaged subgroup spent an average of 709 minutes using the program. Third graders in the students with disabilities subgroup averaged 741 minutes of usage. Fourth grade students spent an average of 632 minutes using the program. Fourth graders in the economically disadvantaged subgroup spent an average of 639 minutes using the program. Fourth graders in the students with disabilities subgroup spend an average of 637 minutes using the software. Fifth grade students spent an average of 659 minutes using the software. Fifth grade students in the economically disadvantaged subgroup spent 659 minutes on overage, and students in the students with disabilities subgroup spent 592 minutes on average using the software.

Results

According to Ary, Jacobs, Razavieh, and Sorenson, ex post facto research can be used "to investigate cause-and-effect relationships when the researcher cannot randomly assign subjects to different conditions" (p. 371). Ary, Jacobs, Razavieh, and Sorenson also confirm that a *t* test is appropriate for studies attempting to measure correlations between variables (p. 196). A two-tailed *t* test for independent samples was used to test each research hypothesis. A two-tailed *t* test was selected for the proposed study, since the possibility existed that students who used the math software could have higher or lower math achievement scores. An alpha level of .05 was used for each test. In the following section, results of the t tests for each of the research hypotheses are provided.

Two-tailed *t* tests for independent samples were used to test each of the six hypotheses. For all of the following data analyses, data was collected from two separate sets of students and can be assumed to be independent of each other. Levene's tests are also provided to compare the population variances between data sets. Based on the results of the Levene's tests, the researcher concluded that it was possible to draw valid conclusions from the *t* tests.

Hypothesis One Testing

Third grade students' scaled scores from the math portion of the CRCT test for 2011-2012 were compared with third grade students' scaled scores from the math CRCT for the 2012-2013 school year. The control group (2011-2012) had a mean score of 826.00 with a standard deviation 38.73. The 2012-2013 group had a mean score of 803.76 with a standard deviation of 31.22. Levene's test indicated there was not a significant difference in the variances of the two groups (F = 1.76, p = 1.87). The researcher decided there were sufficient conditions to run the two-tailed independent samples *t* test. The two-tailed independent samples *t* test with 128 degrees of freedom resulted in a *t* value of -3.49. At an alpha level of .05, there was a statistically significant difference between the two means: the null hypothesis was rejected. Based on these results, the alternative hypothesis was proposed: Third grade students who used the supplemental math software for one year had lower math achievement scores than third grade students who did not use the software.

Hypothesis Two Testing

Fourth grade students' scaled scores from the math portion of the CRCT test for 2011-2012 were compared with fourth grade students' scaled scores from the math CRCT for the 2012-2013 school year. The control group (2011-2012) had a mean score of 812.20 with a standard deviation 36.46. The 2012-2013 group had a mean score of 817.61 with a standard deviation of 32.81. Levene's test indicated there was not a significant difference in the variances of the two groups ($F = 1.22$, $p = 0.27$). The researcher decided there were sufficient conditions to run the two-tailed independent samples *t* test. The two-tailed independent samples *t* test with 148 degrees of freedom resulted in a *t* value of .954. At an alpha level of .05, the results indicated that there was not a statistically significant difference between the two means: there was not sufficient evidence to reject the null hypothesis. Fourth grade students who used the supplemental math software for one year had statistically similar math achievement scores as fourth grade students who did not use the software.

Hypothesis Three Testing

Fifth grade students' scaled scores from the math portion of the CRCT test for 2011-2012 were compared with fifth grade students' scaled scores from the math CRCT for the 2012-2013 school year. The control group (2011-2012) had a mean score of 825.76 with a standard deviation 36.24. The 2012-2013 group had a mean score of 828.26 with a standard deviation of 36.19. Levene's test indicated there was not a significant difference in the variances of the two groups ($F = 0.00$, $p = 0.98$). The researcher decided there were sufficient conditions to run the two-tailed independent samples *t* test. The two-tailed independent samples *t* test with 143 degrees of freedom resulted in a *t* value of .415. At an alpha level of .05, the results indicated that there was not a statistically significant difference between the two means: there was not sufficient evidence to reject the null hypothesis. Fifth grade students who used the supplemental math software for one year had statistically similar math achievement scores as fifth grade students who did not use the software.

The results from the hypotheses tests one through three are detailed in Table 4.3.

Table 2

CRCT Math Score Comparisons (2011-2012 vs 2012-2013)

	School Year						
	2011-2012			2012-2013			
Group	*n*	*M*	*SD*	*n*	*M*	*SD*	*t*
3rd Graders[a]	76	826.00	38.73	54	803.76	31.22	-3.49*
4th Graders[b]	74	812.20	36.46	76	817.61	32.81	0.95
5th Graders[c]	71	825.76	36.24	74	828.26	36.19	0.42

[a]*df* = 128. [b]*df* = 148. [c]*df* = 143.

*p < .05.

Hypothesis Four Testing

Third grade students' scaled scores from the math portion of the CRCT test for 2011-2012 were compared with third grade students' scaled scores from the math CRCT for the 2013-2014 school year. The control group (2011-2012) had a mean score of 826.00 with a standard deviation 38.73. The 2013-2014 group had a mean score of 839.98 with a standard deviation of 50.26. Levene's test indicated there was not a significant difference in the variances of the two groups (F = 3.40, p = 0.07). The researcher decided there were sufficient conditions to run the two-tailed independent samples t test. The two-tailed independent samples t test with 132 degrees of freedom resulted in a t value of 1.819. At an alpha level of .05, the results indicated that there was not a statistically significant difference between the two means: there was not sufficient evidence to reject the null hypothesis. Third grade students who used the supplemental math software in the second year of implementation had statistically similar math achievement scores as third grade students who did not use the software.

Hypothesis Five Testing

Fourth grade students' scaled scores from the math portion of the CRCT test for 2011-2012 were compared with fourth grade students' scaled scores from the math CRCT for the 2013-2014 school year. The control group (2011-2012) had a mean score of 812.20 with a standard deviation 36.46. The 2013-2014 group had a mean score of 811.46 with a standard deviation of 34.68. Levene's test indicated there was not a significant difference in the variances of the two groups ($F = 0.05$, $p = 0.83$). The researcher decided there were sufficient conditions to run the two-tailed independent samples *t* test. The two-tailed independent samples *t* test with 135 degrees of freedom resulted in a *t* value of -0.121. At an alpha level of .05, the results indicated that there was not a statistically significant difference between the two means: there was not sufficient evidence to reject the null hypothesis. Fourth grade students who used the supplemental math software in the second year of implementation had statistically similar math achievement scores as fourth grade students who did not use the software.

Hypothesis Six Testing

Fifth grade students' scaled scores from the math portion of the CRCT test for 2011-2012 were compared with fifth grade students' scaled scores from the math CRCT for the 2013-2014 school year. The control group (2011-2012) had a mean score of 825.76 with a standard deviation 36.24. The 2013-2014 group had a mean score of 838.00 with a standard deviation of 30.55. Levene's test indicated there was not a significant difference in the variances of the two groups ($F = 1.31$, $p = 0.25$). The researcher decided there were sufficient conditions to run the two-tailed independent samples *t* test. The two-tailed independent samples *t* test with 138 degrees of freedom resulted in a *t* value of 2.158. At an alpha level of .05, the results indicated that there was a statistically significant difference between the two means: there was sufficient evidence to reject the null hypothesis. Fifth grade students who used the supplemental math software in the second year had statistically higher math achievement scores than fifth grade students who did not use the software.

The results from the hypotheses tests four through six are detailed in Table 4.4.

Table 3

CRCT Math Score Comparisons (2011-2012 vs 2013-2014)

	School Year						
	2011-2012			2013-2014			
Item	*n*	*M*	*SD*	*n*	*M*	*SD*	*t*
3rd Graders[a]	76	826.00	38.73	58	839.98	50.26	1.82
4th Graders[b]	74	812.20	36.46	63	811.46	34.68	-0.12
5th Graders[c]	71	825.76	36.24	69	838.00	30.55	2.16*

[a]*df* = 132. [b]*df* = 135. [c]*df* = 138.

**p* < .05.

Conclusion

Research question one focused on the differences in math achievement for students who used the supplemental math software during the 2012-2013 year and students in 2011-2012 who did not use the software. Three hypotheses were proposed, one for third grade students, one for fourth grade students, and one for fifth grade students. For hypothesis one, the null hypothesis was rejected, but the alternative hypothesis was accepted. In third grades, students who used the software in 2012-2013 actually had lower math achievement scores than students from the 2011-2012 school year who did not use the software. For hypotheses two and three, there was not sufficient evidence to reject the null hypothesis. There were no statistically significant differences between the CRCT math scores of fourth and fifth grade students who used the software during the 2012-2013 school year and their corresponding grade level students who did not use the software from the 2011-2012 school year.

Research question two focused on the differences in math achievement for students who used the supplemental math software during the second year of implementation, 2013-2014, and students in the 2011-2012 school year who did not use the software. Three hypotheses were proposed, one for third grade students, one for fourth grade students, and one for fifth grade students. For hypotheses four and five, data analyses failed to reject the null hypotheses. Students in grades three and four who used the software during the 2013-2014 school year had statistically similar math achievement scores as corresponding grade level students in 2011-2012 who did not use the software. For hypothesis six, the null hypothesis was rejected. Fifth grade students who used the software in 2013-2014, the second year of implementation, had statistically higher levels of math achievement than fifth grade students during the 2011-2012 school year who did not use the software.

Students used the supplemental math software for a significant amount of time distributed over multiple sessions throughout the school year. In year two of implementation, 2013-2014, students used the software for greater amounts of time, again distributed in weekly sessions throughout the school year. Few consistent differences were found in software usage for students in the economically disadvantaged and students with disabilities subgroups.

The results of comparisons of students' CRCT scaled scores on the math portion of the test suggest that there were few if any statistically significant differences between students who used the supplemental math software and students who did not use the software. Chapter five will present a discussion of these findings, and present some conclusions and recommendations for further research on the use of supplemental math software.

CHAPTER 5: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

The purpose of this study was to investigate the possible relationship between using *Study Island* supplemental math software and student math achievement in third through fifth grade math classrooms in a Title I public school in northwest Georgia. In the past few decades, school leaders have increasingly turned to technology to improve schools and increase student achievement. A 1998 survey revealed that approximately 8.6 million computers were in K-12 classrooms, a number that was growing about 15 percent per year (Becker, 2001).

The Georgia Department of Education has been a leader in funding classroom technology in public schools across the state for the past fifteen years. With the passage of a state lottery in 1993, the state began funding classroom technology with lottery proceeds for every public school district in the state (Georgia Lottery Corporation, 2009). From 1993 to 2003, lottery proceeds funded 1.3 billion dollars' worth of new technology initiatives in public schools in the state (Georgia Lottery Corporation, 2008).

Although classroom computers have been implemented in public schools in a myriad of ways for the past thirty years, the vision of technology transforming teaching and learning has remained largely unfulfilled. When faced with limited resources, educational leaders have been hard pressed to find research based proven models of technology integration that lead to increased student achievement.

A recent review of literature suggests that few studies of recently available technology in elementary school classrooms and its impact on student mathematics achievement have been conducted (Beal, Walles, Arroyo, & Woolf, 2007; Salerno, 1995; Dunleavy & Heinecke, 2007). While computer technology and software have been common additions to many classrooms over the past few decades, educators have limited evidence of their effects on student learning. While studies on educational technology have been prevalent for several decades, the pace of technological innovation, the unique features of local schools in different communities, and the need to provide equitable access to technology resources to all students often limit the applicability of the findings of the research to specific applications in the present. Nevertheless, educational leaders at all levels continue to invest in technology innovations for classrooms. Unfortunately, school systems often invest in technology based on promises from technology vendors, rather than on research based implementation strategies.

In this study, students in grades three, four, and five used a supplemental math software program called *Study Island* during weekly computer lab sessions over the course of an entire school year. Lab sessions lasted approximately 40 minutes and were supervised by a certified elementary school teacher who collaborated with students' regular math teachers (L. Welborn, personal communication, Sep. 23, 2013). Math achievement scores on the statewide standardized test for students in each grade from the first and second years of software implementation were compared with students' math scores from the year before the school implemented the software program.

This chapter provides a summary of the findings organized by research questions and a discussion of the findings in light of the literature review. The implications and limitations of this study are also shared. The chapter concludes with recommendations for future research based on the findings from the study.

Research Questions

To investigate the relationship between the use of *Study Island* math software and the math achievement scores of third, fourth, and fifth grade students, the researcher proposed the following research questions.

RQ1: Is the use of *Study Island,* a supplemental software program, correlated to students' mathematics achievement?

RQ2: Is the use of the supplemental software program *Study Island* during the second year of school wide implementation correlated to students' mathematics achievement?

Summary and Discussion of Findings

As shown by the literature review, some uses of technology have shown significant effects on student math achievement (Kulik and Kulik, 1991; Kulik, 2002; Salerno, 1995; Brush, 1996; et. al.). Most of the studies with positive results have come from software that provides computer aided learning, rather than from teaching students computer programming (Tannenbaum, 2009; Tyler & Vasu, 1995) or allowing students to complete computer simulations or play games (Shaffer, 2006; Doerr & Pratt, 2008).

Drill and practice programs, a subset of computer aided learning, often focus on Piaget's explanation of learning within existing structures of thought, or assimilation (Piaget, 1950). In addition to the results reported from computer aided instruction, computer tutorial programs have also shown some promise to increase student math achievement (Aleven, McLaren, Roll, & Koedinger, 2006; Slavin, 2006; Roll, Aleven, McLaren, & Koedinger, 2007). Tutorial programs are designed to allow students to complete lessons at their own pace, at their current instructional level, and to repeat the lessons as often as needed to achieve mastery (Beal, Walles, Arroyo, & Woolf, 2007). The programs attempt to place students in Vygotsky's zone of proximal development to maximize math learning based on diagnostic and ongoing formative data from students' interactions with the program (Vygotsky, 1978; Beal, Walles, Arroyo, & Woolf, 2007).

The software used in this study was an example of computer aided instruction, since the computer lab teacher assigned lesson modules based on the students' grade level and collaboration with the students' math teachers about their current needs as a class or small groups (L. Welborn, personal communication, Sep. 23, 2013). The software did contain elements of a tutorial program, in that within each module, the program administered a pretest and then provided practice based on the results of the pretest. The program did not allow a student to complete the module until achieving a certain level of accuracy on formative items distributed within and at the conclusion of the module (L. Welborn, personal communication, Sep. 23, 2013). The program also incorporated short video clips to explain math concepts. The use of educational video clips has been widely practiced since the 1960's, but only recently has shown impacts on student achievement (Boster, Meyer, Roberto, Lindsey, Smith, Inge, & Srom, 2004). Finally, the program attempted to motivate students to continue engaging with the lessons by rewarding students with blue ribbons for completing modules. The computer lab teacher reinforced the internal motivation by giving students token prizes for achieving blue ribbons within the program and posting their names and ribbons earned on the walls of the classroom (L. Welborn, personal communication, Sep. 23, 2013). While the availability of instant, repeated explanations, immediate feedback about performance, and internal rewards for completing modules may serve to increase students' motivation to learn math (Offer & Bos, 2009; Roschelle, et. al., 2010), few studies have shown increased achievement due to increased motivation from using computer software.

Studies that fail to show significant gains for students often contain less than ideal implementation of technology, often from allowing too little time for students to use the software (Kulik, 2002). This study attempted to ensure students had adequate time to use the software by including only students who used the software consistently over the course of an academic year.

Results of the statistical analysis were inconsistent with many of the studies that showed gains in math achievement for students who used computer aided learning or tutorial programs. Research question one sought to explore the relationship between the use of *Study Island*, a supplemental math software program, and students' mathematics achievement as demonstrated on a Georgia CRCT. The study found no statistically significant difference between students who used the supplemental math software and students who did not use the software. In fact, third graders from the 2012-2013 school year, the first year of software implementation, actually had statistically significant lower math achievement scores than students from the 2011-2012 school year who did not use the software.

The second research question asked whether the use of the supplemental software program *Study Island* during the second year of school wide implementation was correlated to students' mathematics achievement. The study found no statistically significant difference between the math achievement scores of third graders or the math achievement scores of fourth graders. The only group that showed a significantly higher level of math achievement after using the software was the fifth grade group.

Conclusions

The results of the study did not show a statistically significant relationship between use of *Study Island* supplemental math software and students' math achievement. Whether the lack of a positive relationship was due to faults in the software or an incomplete or faulty implementation of the software at the school in the study remain unclear.

Several possible factors may have impacted the study results. First, while software usage reports showed that students used the software for a significant number of minutes over a two year period, evidence about how closely students' software usage aligned to their zone of proximal development in math, unique learning needs, and math teachers' recommended learning paths was not collected for this study. Further, the school in the study did provide ongoing training for the computer lab teacher who supervised students using the software over the two years of implementation, but did not provide extensive training nor support for regular education and special education math teachers regarding software usage as a curriculum supplement (L. Welborn, personal communication, March 7, 2016). Further training and support for all math teachers regarding the implementation of the software may have the potential to produce different results.

Another possible explanation for the results of the study is that the program relied on prescribed lessons from a classroom or lab teacher to place students in learning modules, and thus may have placed students into learning situations that were either too simple or too complex for their current learning levels. That is, the reliance on assigned lessons was only as effective as the teachers making the assignments and their accurate assessment of students' current zone of proximal development for a specific math topic (Vygotsky, 1978).

Lack of student motivation may have also played a role in the outcome of the study. Many computer software programs rely on Pavlovian or Skinnerian type reinforcers, such as tokens or internal certificates (Slavin, 2006; Wood, 1998; Borsch, 2008). While the program attempted to motivate students with immediate and repeated instruction, immediate feedback, and internal blue ribbons for completing modules, informal interviews with the school's academic coach revealed that students sometimes resisted engaging in the lessons for extended periods of time (L. Welborn, personal communication, May 30, 2014). Students frequently asked the computer lab teacher whether they could close out the program and go to their favorite gaming websites, sites that may or may not have been educational in nature (L. Welborn, personal communication, May 30, 2014). Again, the implementation of the software thus depended on the vigilance of the computer lab teacher in ensuring that students were engaging in meaningful ways with the lessons in the program. The software program measured students' usage in minutes, and included a timeout feature to prevent students from logging into the program and then doing other activities while the software sat idle (Magnolia, 2009). While the software recorded an average use of 338 – 415 minutes in the first year of implementation and 592-741 minutes of use in the second year, some students may have interacted with the program in a random fashion, without fully attending to the lessons, learning tasks, or assessment probes.

A third possible explanation is that students' use of the program was spread out too much to have lasting effects on student achievement. While students were regularly scheduled to work with the program in weekly lab sessions, the schedule was often interrupted by school holidays, snow days, standardized testing, and state mandated surveys (L. Welborn, personal communication, May 30, 2014). A more concentrated use of the software may have allowed students to maintain more consistency in their learning and progress within each learning module.

The composition of the students within each grade level may also have affected the study. While statistical safeguards were in place to measure the comparability of the math scores among groups, the scores in each group were from different students attempting to learn the same math curriculum. An informal interview with the school's academic coach did reveal a consistency in the math teachers across the three years in the study, but the itinerant rate at the school was approximately 30% during the study years (L. Welborn, personal communication, May 30, 2014). Interestingly, the third graders from the first year of software implementation that showed an overall average math score decrease when compared with the third grade control group also scored lower as fourth graders than the fourth grade control group. It could be argued that this group had lower overall math achievement before entering the third grade in 2012-2013 than the group that completed third grade in 2011-2012 (control group). However, the researcher had no other evidence that suggested the groups' math achievement levels differed upon entering third grade.

A more theoretical explanation may lie in the program's tendency to attempt to teach new skills or concepts, rather than supplementing the regular math teacher's classroom instruction. While the assigned modules were appropriate for each grade curriculum, some students may have missed significant amounts of classroom instruction due to attendance issues, off task behaviors, or teacher absences. These students, then, would not have the new learning of their peers before encountering the lesson module content in the computer lab. That is, rather than offering the chance to reinforce or extend learning, some students may have been encountering math lessons that were new or beyond their current learning. In Piaget's terms, the program may have been requiring students to change mental schemes to accommodate the new learning.

Finally, students may have had more success in using the software to learn math in a collaborative setting. At least one study showed promising results for students who worked with computer aided instruction in small groups (Fitzpatrick, 2001). The study seemed to indicate that students' tendency to ask a peer who had higher math achievement for help accounted for much of the increase in achievement (Fitzpatrick). This use of peer helpers seems in line with Vygotsky and Burner's theories of learning through guidance from someone slightly more knowledgeable. While students in the current study were allowed to ask the computer lab teacher for help while completing modules, no attempts were made to allow them to help each other or put them into groups during either year of implementation (L. Welborn, personal communication, May 30, 2014).

Implications

Since the current study did not find statistically higher levels of math achievement for students in five of the six groups who used the supplemental math software, it cannot be considered as evidence of a positive relationship between using this software program and students' math achievement. While fidelity of implementation regarding the number and length of usage was maintained over a relatively long period of use, the use of the program was not associated with higher levels of math achievement. In fact, achievement levels were actually lower for two of the six groups who used the software than their corresponding groups who did not use the software.

While the makers of the software would probably argue that students needed to use the software even more during the school year to show significant results, any school has a limited amount of instructional time during the school day. The school invested in the physical resources of a computer lab, the human resources of a certified lab teacher, and the instructional time in weekly use over the course of an academic year. As such, the school's investment over two years represents a significant amount of resources and time. A major shortcoming of the school's implementation of the software, however, may be the lack of ongoing training and support for all math teachers about the degree of customization of each learning module to individual student's learning needs (L. Welborn, personal communication, May 30, 2014). While several software programs seem to have the potential to help students increase math achievement (Aleven, McLaren, Roll, & Koedinger, 2006; Slavin, 2006; Roll, Aleven, McLaren, & Koedinger, 2007; et. al.), the program implementation in the school in this study was not associated with higher levels of math achievement by students.

Limitations

This study has several limitations. The first limitation is the design of the study. Since the study attempted to investigate any possible relationship between using supplemental math software and math achievement among elementary students, equity issues prevented the researcher from using a purely experimental design. That is, random assignment of some students to use the software could have also resulted in randomly denying other students the opportunity to use the software. This lack of randomization in favor an investigation of historical data for a school that started using software with all students at a given point in time limits the findings from any sort of statement of causality. The study design was also chosen to ensure that students would engage in significant use of the software over extended periods of time, a limitation that seems to have affected numerous previous studies.

This study lacked a pretest for each group of students administered at the beginning of the school year on each grade level curriculum. Such a pretest could have helped control for external factors like preexisting math learning, teacher differences, and interruptions to the academic schedule from year to year. While the teachers providing math instruction were consistent at the school over the course of the study, teachers may miss more days due to teacher absences in some years or be more or less instructionally effective due to personal periods of growth or life events.

The school's implementation of the software in this study may be a major factor in explaining the study results. While the school in the study did provide ongoing training for the computer lab teacher who supervised students using the software over the two years of implementation, it did not provide extensive training nor support for regular education and special education math teachers regarding software usage as a curriculum supplement (L. Welborn, personal communication, March 7, 2016). Further training and support for all math teachers regarding the implementation of the software may have the potential to produce different results for schools choosing to implement this or other supplemental software. Schools considering implementing this or other supplemental software may need to consider investing in extensive and ongoing teacher training and support throughout the first few years of implementation to ensure a high quality of software use by students.

Finally, the participants in this study were also from one school in one region of Georgia, which may limit the findings from being applicable to students in other schools in other regions or countries. The study also relied on scaled scores from a statewide standardized test to operationalize students' math achievement. This reliance on a test instrument from one state could limit findings for students in other states who are assessed with different instruments.

Recommendations for Future Research

Further research needs to be conducted with the software program in this study and other similar programs currently in use in schools to help students increase math achievement. Studies involving students in other schools and other regions of the country could show markedly different results and thus contribute to the growing body of research about the effectiveness of supplemental math programs. Studies with larger groups from multiple schools also have the potential to show whether the use of the software has any effect on math achievement among students from backgrounds different than the students in this study. Future studies could include more national or international standardized test instruments to operationalize student math achievement to make the results more broadly applicable to a wider range of students. The use of an assessment instrument as a pretest and posttest to measure growth in students after using software or not, may also help control for outside factors that can significantly impact student achievement. Future studies should consider using benchmark tests as a pretest and posttest measure to help move the research toward a more experimental approach. Benchmark tests could also provide more narrow assessments over smaller portions of the math curriculum to measure possible effects of software usage over shorter implementation periods to help guard against limitations associated with larger study durations and standardized assessments. Future studies should also attempt to gather evidence of teacher training and support for all math teachers, including regular education and special education classroom teachers, regarding software over the course of the implementation period. Finally, study designs that are more experimental in nature may be able to establish more causal links between software use and student achievement than the current study.

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APPENDICES

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

October 21, 2014

Michael Rich
IRB Exemption 1956.102114: The Relationship between Using Study Island Supplemental Math Software and Third-, Fourth-, and Fifth-Grade Students' Math Achievement

Dear Michael,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and that no further IRB oversight is required.

Your study falls under exemption category 46.101 (b)(4), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:

> (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Please note that this exemption only applies to your current research application, and that any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption, or need assistance in determining whether possible changes to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,

[redacted]

Fernando Garzon, Psy.D.
Professor, IRB Chair
Counseling

(434) 592-4054

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July 30, 2014

Mr. Michael Rich
337 Bent Tree Drive
Ringgold, GA 30736

Dear Mr. Rich:

Based on my review of your research proposal, the system grants you permission to conduct the study entitled "The Relationship Between Using *Study Island* Supplemental Math Software and Third, Fourth, and Fifth Grade Students' Math Achievement" within the Catoosa County Public Schools organization. This permission is granted on the basis that procedures are established that ensure the privacy of students and staff. These procedures will need to be reviewed and approved by Dr. Nichols.

As Georgia educators, we are also all required to follow the standards established in the Georgia Professional Standards Commission Code of Ethics. We reserve the right to withdraw from the study at any time if our circumstances change. I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the research team without permission of the Liberty University Institutional Review Board (IRB).

Sincerely,

[redacted]

Dr. Kim Nichols
Assistant Superintendent
Catoosa County Public Schools

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