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Ubiquitous Computing in Public Education: The Effects of One-to-One Computer Initiatives on Student Achievement on Florida Standardized Assessments

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UBIQUITOUS COMPUTING IN PUBLIC EDUCATION: THE EFFECTS OF ONE-TO-ONE COMPUTER INITIATIVES ON STUDENT ACHIEVEMENT ON FLORIDA STANDARDIZED ASSESSMENTS

by

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ABSTRACT

The purpose of this study was to examine the effects of one-to-one computer initiatives on student achievement in reading and mathematics. This study compared the differences in FCAT 2.0 Reading and Mathematics scores between schools implementing one-to-one computer initiatives and schools implementing traditional modes of instruction. A second purpose of this study was to determine what effects one-to-one computer initiatives had on student FCAT 2.0 scores overall and by grade level, gender, and socio-economic status.

The study used an independent-samples t-test, a repeated measures ANOVA, and a factorial ANCOVA to answer four research questions in order to achieve the purpose stated above. An analysis of the results revealed that the first year of one-to-one initiatives had a slightly negative effect on elementary school students, a small but positive effect on middle school students, and no effect on high school students. Further, the study found that students did not score statistically significantly different after one year of one-to-one digital instruction than they had the previous year.

As a Cuban immigrant and first generation college student, the chances of obtaining a bachelor's, let alone a doctorate degree, were slim to none. In "Giants among Us", Sandria Rodriguez wrote that in order for disadvantaged children to succeed, they must "switch the track" they are on. Switching tracks is a monumental task that is rarely done alone; it truly was a group effort.

This dissertation is dedicated to all the women who, knowingly or not, helped me "switch the track". There is no way I could have accomplished so much, without many, many people believing in me and encouraging me along the way. This accomplishment is dedicated to my mentors, Rosa Cintron and Laura Beusse, who always believed in me even when I doubted myself; my friend, Willys Michel, who has travelled this lonely path by my side; my step-dad, Antonio Escalona, who raised me as his own son to be the man I am; my mother, Devorah Rosello, who has always been my biggest supporter and advocate; and my wife, Melanie Lobeto, who has suffered through this journey as much as I have (if not more).

Lastly, this dissertation is dedicated to my daughters, Aolani, Giselle, and Isabela. It is for you that I started down this path, and it is for you that I continue to strive for greatness. Let my experience serve as an example of everything you can accomplish with the right attitude and work ethic.

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CHAPTER I: INTRODUCTION

Background of the Study

Digital learning has been a topic of interest since the 1970s when researchers sought to correlate computer assisted instruction and simulations to student achievement (Hattie, 2009). More recently—beginning in the mid-1990s with Microsoft's Anytime Anywhere Learning Program®—researchers have focused on one-to-one computer initiatives and their effects on student academic achievement. One-to-one initiatives, also referred to as ubiquitous computing, provide students with laptop computers, tablets, or some other form of networked technology to use ubiquitously at school (and sometimes at home) for the entirety of the school year. Teachers at one-to-one schools are expected to teach using technology as a primary tool for delivery of instruction; student tasks and activities; and assessment. Ideally, school districts provide teachers with adequate professional development in the areas of digital instruction and assessment, and with plentiful digital resources to achieve their objectives, including digital texts and educational applications (Florida Statutes, 2013a). Currently, more than two decades since the inception of the idea, one-to-one initiative implementation practices have varied across the country with mixed results (Penuel, 2006).

Studies have reported a range of findings, including significant improvement in student academic achievement in general and in reading (Hattie, 2009; Lee, Waxman, Wu, Michko, & Lin, 2011; Liao, Chang, & Chen, 2008; Moran, Ferdig, Pearson, Wardrop, & Blomeyer, 2008; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011); little or no improvement in student academic achievement in reading or mathematics (Cheung & Slavin, 2013a; Cheung & Slavin, 2013b; Li & Ma, 2010; Zucker, Moody, & McKenna, 2009); and improvement in other areas such as equity of access; more effectively preparing students for the workforce; transforming the quality of instruction; and increasing economic benefits (Penuel, 2006; Topper & Lancaster, 2013). Researchers also have indicated development of 21st century skills (Mouza, 2008; Rockman, 2003); increased active engagement; participation in groups; frequent interaction and feedback; and connection to real-world contexts (Mouza, 2008; Roschelle et al., 2000); improved writing skills (Mouza, 2008; Penuel, 2006; Russell, Bebell, & Higgins, 2004); improved attitude towards school (Mouza, 2008); and motivation and persistence in completing work (Mouza, 2008) as learning benefits derived from ubiquitous computing programs.

In 2013, the school district being studied introduced a one-to-one computer initiative in seven of its schools (referred to as digital pilot schools) (OCPS, 2014a). The school district's rationale for its digital pilot program includes academic, economic, and industrial drivers concerned with better preparing students for college and the workforce:

> In Florida, students are considered college and career ready when they have the knowledge, skills, and academic preparation needed to enroll and succeed in introductory college credit-bearing courses within an associate or baccalaureate degree program without the need for remediation. These same attributes and levels of achievement are needed for entry into and success in postsecondary workforce education or directly into a job that offers gainful employment and career advancement. (Digital Curriculum Steering Committee, n.d., p. 6)

In addition, the decision to implement the digital pilot program also was tied to the national shift away from paper-based assessments towards digital assessments (Digital Curriculum Steering

Committee, n.d.). In response, the school district shifted its district-wide assessment to digital delivery and its instructional pedagogy to Problem-Based Learning and Web-Enhanced Instruction (Digital Curriculum Steering Committee, n.d.).

Despite the wealth of learning benefits identified by researchers, few studies have analyzed the impact of one-to-one initiatives on student academic achievement as measured by state and federal agencies; using standardized assessments (Penuel, 2006). Furthermore, earlier studies focused on the tool itself (laptop computers) while more recent studies have shifted to examine more specifically the effects of networked computers which give students immediate and limitless access to information. This study will examine the mean scores on the Florida Comprehensive Assessment Test (FCAT) 2.0 Reading and Mathematics of elementary, middle, and high school students using one-to-one computers in a large urban school district in Florida. Empirical research on ubiquitous computing is scant and that which exists is contradictory and raises many questions regarding implementation practices, student learning outcomes, age of students, gender, and subject area being taught. With the increasing attention being given to school accountability and student outcomes on state standardized assessments, and the continued spread of one-to-one initiatives across the country, these questions require examination if school districts are to continue spending millions of dollars implementing one-to-one initiatives, many of which have failed in the past (Penuel, 2006).

Statement of the Problem

School districts across the country have opted to implement one-to-one initiatives in their schools with limited and conflicting research regarding the effects of ubiquitous computing on student academic achievement. To date, there is limited information concerning the academic outcomes of ubiquitous computing. Although many school districts do not list improved academic achievement as an expected outcome of one-to-one initiatives (Mouza, 2008; Penuel, 2006; Topper & Lancaster, 2013; Rockman, 2003; Roschelle et al., 2000; Russell, Bebell, & Higgins, 2004), it is irrefutable that student academic achievement is the primary focus of school districts, state and national legislators, and the American public as evidenced by the bevy of policies geared toward greater accountability for student learning in recent years and school district missions across the country (No Child Left Behind [NCLB], 2002; Ravitch, 2011; United States Department of Education [USDOE], 2014). Despite the importance of the reasons school districts might implement one-to-one initiatives, student academic achievement should be the foremost reason and must be examined more in-depth.

Purpose of the Study

The purpose of this study was to examine the effects of one-to-one computer initiatives on student achievement in reading and mathematics. This study compared the differences in participating students' FCAT 2.0 Reading and Mathematics scores after one-to-one initiative implementation to the scores of a random sample of students in the district. A second purpose of this study was to determine what effects one-to-one initiatives had on students by grade level, gender, and socio-economic status (SES).

Significance of the Study

According to Florida Statutes (2013a), state legislation requires that by the 2015-2016 school-year, 50% of instructional materials purchased are either digital or electronic. Additionally, the Florida Department of Education (FLDOE) requires a one-to-one student-to-device ratio by 2017-2018; therefore, it is imperative to assess the educational outcomes of the one-to-one initiative, both short and long-term. While large-scale studies were not feasible given inconsistent assessments among states, a district-wide study comparing students in schools implementing one-to-one initiatives to students in schools using traditional modes of instruction may help determine the effectiveness of the initiative and also add substantially to the body of knowledge regarding the effects of one-to-one initiatives on student academic achievement.

The results of this study will add to the scarce body of literature regarding student achievement on state standardized assessments and provide school leaders with more information about a high-priced intervention. In particular, this study compared mean student scores on standardized assessments between students who received one-to-one digital instruction and those who received traditional modes of instruction. Thus providing school leaders with the knowledge to make prudent decisions in regards to one-to-one initiative implementation. According to Penuel (2006), “A significant number of experimental and quasi-experimental studies are needed if laptop programs are to provide stronger research-based evidence warranting investments in one-to-one initiatives” (p. 342).

Definition of Terms

For the purpose of this study, the following definitions apply:

One-to-One Initiatives: An academic intervention in which schools provide students with networked digital devices such as laptops, tablets, or other hand-held devices with wireless internet connectivity for the entirety of the school year. The intervention creates a ubiquitous environment in which students use the digital devices in school and at home for educational purposes. Also referred to as ubiquitous computing, one-to-one schools, and digital pilots.

Traditional Instruction: Any form of instruction that does not include ubiquitous digital learning or web-based learning as its primary mode of instruction. Schools implementing traditional instruction will serve as the comparison group to schools implementing one-to-one initiatives.

Student Achievement: Student growth on state standardized assessment scores in reading and mathematics and as compared to students who have not received the academic intervention.

FCAT 2.0: The standardized state assessment in Florida from 2011 through 2014. The test was discontinued for the 2014-2015 school year in favor of the Florida Standards Assessment (FSA). FCAT 2.0 scores were used for high school graduation and school grading purposes and were met with major controversy, especially during the later years.

Florida Standards Assessment (FSA): The new standardized assessment for the state of Florida beginning with the 2014-2015 school-year. The FSA was developed by the American Institute for Research and is aligned with the Florida Standards in order to provide educators and families with information about student learning. Students in grades 3-10 will be administered an English language arts assessment with writing components in grades four and 10; students in grades 3-8 will be administered a mathematics assessment; and high school level students will be administered algebra 1, geometry, and algebra 2 end of course exams (FSA, 2014).

Knowledge: The ability to respond immediately to the changing elements of the learning environment (actionable knowledge). "Learning (defined as actionable knowledge) can reside outside of ourselves (within an organization or a database)" (Siemens, 2004, p. 4).

Next Generation Sunshine State Standards (NGSSS).

Theoretical Framework

With the current emphasis on accountability for student achievement, recognizing successful interventions from unsuccessful ones is essential. "States and district school boards must often choose between funding different compelling kinds of programs for students; data on effectiveness can help inform their decision-making process" (Penuel, 2006, p. 342). For one-to-one initiatives to be effective, research on implementation practices and student outcomes must be conducted so that school districts can make informed decisions and understand best practices in regards to one-to-one initiatives.

Siemens (2004) developed a learning theory he termed connectivism. Siemens (2004) claims that the prevailing learning theories—behaviorism, constructivism, and cognitivism—were developed in a time when technology did not play a substantial role in learning. He further states that learning theories must be reflective of the underlying social context in which people live and learn; therefore, as technology has evolved, learning theory must also evolve with it. In the past, learners could go through school and learn what they needed for a lifetime; however, that is no longer the case as the knowledge shelf-life has been significantly reduced to years or even months (Siemens, 2004). In other words, the knowledge required for careers changes more rapidly than in the past and in many cases is obsolete by the time students enter the workforce. It is feasible that the information students learn in some fields could be outdated by the time they graduate college and enter the workforce, making stored knowledge less desirable than the ability to obtain knowledge.

"Connectivism is the integration of principles explored by chaos, network, and complexity and self-organization theories" (Siemens, 2004, p. 6). Chaos theory suggests that the learner must identify patterns of knowledge that initially seem to be disorganized and unrelated. The learner must, therefore, be capable of deriving meaning by forming connections between loosely related communities of information. A network is simply a connection between communities, ideas, or entities. This idea is relevant to chaos theory which requires the learner to make connections between communities of knowledge. Finally, self-organization refers to the individual capacity of the learner to form connections between sources of information to make meaning (Siemens, 2004). In short, connectivism takes a more modern perspective of learning in which students search for and identify relevant information, make meaning, and connect that information to other relevant information to build knowledge.

Connectivism functions under the assumption that knowledge is rapidly changing as new information is constantly acquired, and it is more important to connect information sets that enable learners to learn than the current knowledge of the learner. The principles of connectivism, as stated by Siemens (2004), are as follows:

- Learning and knowledge rests in diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.

- Learning may reside in non-human appliances.
- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.
- Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision. (p. 6)

This study is grounded in connectivism theory. One-to-one initiatives aim, in part, to build 21st century skills in students as well as to improve academic achievement and prepare students for the workforce. Connectivism theory accounts for social contexts (i.e. 21st century skills) in its views of learning and seeks to define learning from a more pragmatic perspective. One-to-one initiatives create ideal conditions for learning as described by connectivism theory. For example, connecting information sources, recognizing a diversity of opinions, developing a capacity to learn more, nurturing and maintaining connections, and maintaining current knowledge are made easier with technology than without as students have networks of information at their disposal to research and apply knowledge immediately to real-life contexts. In essence, students search for information, discriminate relevant from irrelevant sources, identify important pieces of knowledge, and then connect them to other relevant sources of information—all within one class period and with one single tool (their digital devices). Under connectivism theory, teachers no longer are considered keepers of knowledge. Rather, their roles have evolved with the development of technology to facilitators of learning because more important than what students are learning is that they are learning how to acquire knowledge. Connectivism theory helps to explain how learning takes place for students who learn under the conditions set forth in the one-to-one initiatives.

Research Questions

This study measured several variables. The independent variable was the academic intervention (one-to-one digital instruction or traditional instruction). The covariates that were used were gender (male or female), grade level (elementary, middle, and high school), SES (free or reduced lunch status), and academic subject (language arts or math). The dependent variables were student scores on FCAT 2.0 Reading and Mathematics assessments. The following research questions guided this study:

1. What is the difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction?

   H_{01}: There is no statistically significant difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction.

2. What is the difference in FCAT 2.0 Mathematics scores between students in elementary and middle schools implementing one-to-one initiatives and students receiving traditional modes of instruction?

H_{02}: There is no statistically significant difference in FCAT 2.0 Mathematics scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction.

3. What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?

   H_{03}: There is no difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender

4. What is the difference in student academic achievement growth in FCAT 2.0 Mathematics scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?

   H_{04}: There is no difference in student academic achievement growth in FCAT 2.0 Mathematics scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender.

Limitations

The study has the following limitations:

1. The sample of schools was drawn from a single school district; therefore, results may not be generalizable to the entire state or to all states.
2. School implementation of one-to-one initiatives may vary by school site.
3. Teacher competency and digital literacy may vary by school site.

4. The standardized state assessment for reading and mathematics was changed after the first year of program implementation, limiting this study to only the first year of the one-to-one initiative.
5. Many variables outside the control of the researcher could impact student academic achievement besides the intervention. These variables include: student proficiency, family involvement, community involvement, quality of school facilities, quality of instruction, school infrastructure, school leadership, and faculty and student buy-in.

Delimitations

The delimitations utilized by the researcher in this study were determined in order to obtain immediate data from a school district in the early stages of one-to-one initiative implementation. The following delimitations were used:

1. The study only analyzed the first year of the one-to-one initiative. Further studies documenting long-term implementation are required.
2. The study used only students from one school district to compare to initiative schools. The use of a single school district did not allow the researcher to compare one-to-one schools to students in the state.
3. The study used FCAT 2.0 Reading and Mathematics scores at the exclusion of End of Course (EOC) Exams, FSA Reading and Mathematics, and District Benchmark Exams. FCAT 2.0 scores are no longer relevant because Florida has moved to the FSA as its standardized assessment; however, the FSA has yet to be tested in the state and the FCAT 2.0 provided

nearly two decades of data to compare; therefore, FCAT 2.0 scores, rather than the first year of FSA scores, were used for assessment of academic achievement.

Assumptions

This study includes the following assumptions: (a) the data provided by the school district was accurate and current; (b) the program schools implemented the one-to-one initiative faithfully in accordance to district guidance; (c) the comparison schools were appropriately matched to the program schools; (d) the assessment tool was a valid measure of student academic achievement; and (e) the selected schools were a typical sample of the district population.

Methodology

Research Design

This study used a pretest-posttest control-group design (Gall, Gall, & Borg, 2007) to determine (a) the difference between student academic achievement in schools implementing one-to-one initiatives and schools implementing other traditional modes of instruction; (b) the effects of one-to-one initiatives on student outcomes overall; and (c) the effects of one-to-one initiatives on student academic achievement by grade level, SES, and gender. The dependent variable in this study was student academic achievement as measured by FCAT 2.0 Reading and Mathematics scores; the independent variable was one-to-one initiative implementation; and the moderators were student grade level, student gender, and student SES.

Population

This study was conducted in one of the largest urban school districts in Florida. Seven schools, representative of the school district, implemented the one-to-one initiative—one high school, three middle schools, and three elementary schools—"including a range of geographic areas, demographics, socio-economic statutes, and digital readiness levels" (OCPS, 2014a, p. 7). The seven digital pilot schools along with a random sample of students district-wide were included, totaling about 16,000 students.

Data Collection

The district had completed the second year of the initiative (2014-2015) at the time that data was collected. However, the assessment tool used by the state to assess student academic achievement (FCAT 2.0) was changed between the first and second year of implementation and a new, untested assessment, was developed by the state (FSA). As a result, data for the 2014-2015 school-year were not used to maintain consistency.

Data was collected from the district office for one-to-one initiative schools as well as a stratified random sample of schools for two school years; 2012-2013 and 2013-2014. The 2012-2013 school year data was used as a baseline for each student and the 2013-2014 data was used to analyze differences in student achievement as measured by the FCAT 2.0 Reading and Mathematics. The data was then analyzed to determine mean differences in student achievement.

Data Analysis

Quantitative data for student academic achievement on the FCAT 2.0 Reading and Mathematics assessments was analyzed for mean differences for the two years of the study. Two statistical analyses were used in this study: (1) an independent-samples t-test was used to determine the mean difference between student academic achievement for one-to-one schools and the sample population; and (2) repeated measures analysis of variance (ANOVA) was used to determine the relationship between one-to-on initiatives, gender, SES, and subject area. Table 1 shows the research questions, variables, data sources, and analysis that were used to answer each of the research questions.

Table 1: Research Questions, Variables, Data Sources, and Methods of Analysis

Research Questions	Variables	Data Sources	Analysis
1. What is the difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction?	Dependent: FCAT 2.0 Reading scores Independent: One-to-one initiative implementation	2013-2014 FCAT 2.0 Reading scores	Independent-Samples T-test
2. What is the difference in FCAT 2.0 Mathematics scores between students in elementary and middle schools implementing one-to-one initiatives and students receiving traditional modes of instruction?	Dependent: FCAT 2.0 Mathematics scores Independent: One-to-one initiative implementation	2013-2014 FCAT 2.0 Mathematics scores	Independent-Samples T-test
3. What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?	Dependent: FCAT 2.0 Reading scores, one-to-one schools Independent: Student Gender Student SES Student Grade Level	2012-2013 and 2013-2014 FCAT 2.0 Reading scores	Factorial ANCOVA And Repeated Measure ANOVA
4. What is the difference in student academic achievement growth in FCAT 2.0 Mathematics scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?	Dependent: FCAT 2.0 Mathematics scores, one-to-one schools Independent: Student Gender Student SES Student Grade Level	2012-2013 and 2013-2014 FCAT 2.0 Mathematics scores	Factorial ANCOVA and Repeated Measure ANOVA

Organization of the Study

This research study is presented in five chapters. Chapter I includes the background of the study, statement of the problem, purpose of the study, significance of the study, definition of terms, theoretical framework, research questions, limitations, delimitations, methodology, and assumptions.

Chapter II contains a review of the literature which includes digital learning, student achievement, and implementation practices. Chapter III describes the methodology used for this study. It describes the participants, the assessment tools, data collection, and data analysis procedures.

Chapter IV presents the study's findings including student academic achievement by intervention type, student demographic data, testing of the research questions, and analysis of the research questions. Chapter V provides a summary of the study, including discussion of the findings, implications, recommendations for further research, and conclusions.

CHAPTER II

According to s. 1003.41, Florida Statutes, "Curricular content for all subjects must integrate critical-thinking, problem-solving, and workforce-literacy skills; communication, reading, and writing skills; mathematics skills; collaboration skills; contextual and applied-learning skills; technology-literacy skills; information and media-literacy skills; and civic-engagement skills" (Florida Statutes, 2013a, para. 1). Although technology-literacy and media-literacy skills are only a part of many areas of curricular focus, much has been made about improving students' technology skills and closing the digital divide (Zucker, 2004). In response, initiatives like the digital pilot program in Florida have been implemented in many school districts nationwide (Zucker, 2004). S. 1006.29, Florida Statutes, states that all instructional materials adopted by school districts beginning with the 2015-2016 school year must be provided in an electronic or digital format. S. 1006.29, Florida Statutes (2013b), defines electronic and digital formats as follows:

> Electronic format" means text-based or image-based content in a form that is produced on, published by, and readable on computers or other digital devices and is an electronic version of a printed book, whether or not any printed equivalent exists. "Digital format" means text-based or image-based content in a form that provides the student with various interactive functions; that can be searched, tagged, distributed, and used for individualized and group learning; that includes multimedia content such as video clips, animations, and virtual reality; and that has the ability to be accessed at any time and anywhere. (para. 2)

As a result of the increasing demands for technology-literacy, many school districts across the nation, and some in Florida, have opted to introduce ubiquitous computing in their schools. S.1006.282, Florida Statutes (2013c), titled Pilot program for the transition to electronic and digital instructional materials, states that school districts may designate pilot schools to transition to electronic or digital instructional materials as defined above. S.1006.282, Florida Statutes (2013c), outlines the provisions under which a school district may designate a pilot program school. In order to designate a pilot program school, the school district must "implement a local instructional improvement system pursuant to s. 1006.281" (para. 2), which requires seamless connectivity to professional development, instructional materials, and student assessment data. Additionally, the school district must request instructional materials exclusively in electronic or digital format, and it must spend at least 50% of its allocation to pilot program schools for the purchase of those instructional materials.

The FLDOE (2012a) has also established a six-year timeline for transitioning to digital instruction statewide from the 2010-2011 school-year to the 2015-2016 school-year. Table 2 shows the timeline that includes transitions in legislation, instructional materials, digital assessments, and common core standards. Beginning in the 2015-2016 school year all instructional materials purchased by school districts must be made available in digital format and at least 50% of the funding allocated to school districts must be used to purchase digital or electronic instructional materials (FLDOE, 2012a). Additionally, by the 2015-2016 school year districts will be required to purchase instructional materials in mathematics, science, social studies, reading, and language arts; adopt digital assessments and implement common core standards in all grades k-12 (FLDOE, 2012a).

Table 2: Six-year Timeline for Moving Florida's Instruction to the Digital World

	2010-2011	2011-2014	2015-2016
Legislation	1. Publisher provides electronic content for adoption review 2. Districts are allowed to use appropriated funds to purchase technology hardware to support instruction if all instructional purchases and requirements have been met	1. A district school board may designate pilot program schools to implement the transition to instructional materials that are in a electronic or digital format… 2. By August 1 of each year, beginning in 2011, the school board must report to the Department of Education the school or schools in its districts which have been designated as pilot program schools. 3. By April 15, the commissioner shall appoint three state or national experts in the content areas submitted for adoption 4. The commissioner shall request each district school superintendent to nominate one classroom teacher or district-level content supervisor to review two or three of the recommended submissions for instructional usability 5. A publisher may also offer sections of state-adopted instructional materials in digital or electronic versions at reduced rates to districts, schools, and teachers. 6. The term of adoption of any instructional materials must be a 5-year period beginning on April 1 following the adoption	7. Beginning with specifications released in 2014, the digital specifications shall include requiring the capability for searching by state standards and site and student-level licensing 8. The advertisement shall give information regarding digital specifications that have been adopted by the department, including minimum format requirements that will enable electronic and digital content to be accessed through the district's local instructional improvement system and mobile devices. 9. Beginning in the 2015-2016 school year, all adopted instructional materials for students in kindergarten through grades **12** must be provided in electronic or digital format 10. By the 2015-2016 fiscal year, each district school board shall use at least 50 percent of the annual allocation for the purchase of digital or electronic instructional materials included on the state-adoption list

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Instructional Materials Purchased	Mathematics	Science	Social Studies	K-5 Reading, Language Arts, Mathematics	6-12 Reading, Language Arts, Mathematics
Digital Assessment	Algebra I EOC, Grade 10 Math, and Grade 10 Math Retakes	Algebra 1, Geometry, Biology, and U.S. History EOCs; Grades 6 and 10 Reading, Grade 10 Math FCAT Retakes, Reading Retakes and PERT	Algebra 1, Geometry, Biology, U.S. History, and Civics EOCs; Grades 6, 7, 9 and 10 Reading; Grade 5 Math, Grade 10 Math FCAT Retakes, Reading Retakes and PERT	Algebra 1, Geometry, Biology, U.S. History, and Civics EOCs; Grades 6, 7, 8, 9, and 10 Reading; Grades 5 and 6 Math; Grade 10 Math FCAT Retakes, Reading Retakes and PERT PARCC at sample schools – grades 3-11 ELA and Grades 3-8 Math and HS Math EOCs	Algebra 1, Geometry, Biology, U.S. History, and Civics EOCs; Grades 6, 7, 8, 9, and 10 Reading; Grades 5 and 6 Math; Grade 10 Math FCAT Retakes, Reading Retakes and PERT PARCC – grades 3-11 ELA and Grades 3-8 Math and HS Math EOCs
Common Core Standards		Kindergarten and Literacy K-12	Kindergarten and First grade and Literacy K-12	Kindergarten – Second grade; Blended grades 3-12; Literacy K-12	All Grades

Retrieved from: *Florida Department of Education.* (2012a). *Six-year timeline for moving Florida's instruction to the digital world.* Retrieved from www.fldoe.org/fldlg/doc/SixYearTimeline.doc

Ubiquitous computing programs have become increasingly popular in school districts across the United States. However, with tightening budgets nationwide and increased attention to accountability, school districts must be cautious when contemplating ubiquitous computing programs, as they are expensive to initiate and maintain (Zucker, 2004). Rationales for implementing ubiquitous computing programs vary by district. However, six major objectives were cited in the literature by districts implementing ubiquitous computing programs: (1) eliminating computer labs; (2) improving academic achievement; (3) improving equity of access; (4) more effectively preparing students for the workforce; (5) transforming the quality of instruction; and (6) increasing economic benefits (Penuel, 2006; Topper & Lancaster, 2013).

Several researchers have indicated learning benefits derived from ubiquitous computing programs, including development of 21st century skills (Mouza, 2008; Rockman, 2003); increased active engagement; participation in groups; frequent interaction and feedback; and connection to real-world contexts (Mouza, 2008; Roschelle et al., 2000); improved writing skills (Mouza, 2008; Penuel, 2006; Russell, Bebell, & Higgins, 2004); improved attitude towards school (Mouza, 2008); and motivation and persistence in completing work (Mouza, 2008). Additionally, Mouza (2008) states, “Such opportunities are particularly useful in developing the higher-order skills of critical thinking, analysis, and inquiry that are necessary for success in the 21st century” (p. 449).

Other research, on the other hand has found that a one-to-one laptop to student ratio is not necessary for optimal learning gains. Larkin (2011) studied a seventh grade classroom in an Australian primary school to determine the difference between student learning, productivity, engagement, and social activity in classrooms that contained a one-to-one ratio of students to computers and classrooms that contained a one-to-two ratio. Larkin (2011) argues that “one-to-two (1:2) computing is particularly beneficial in regard to student learning, classroom collaboration, and pedagogic approach, and that 1:2 computing offers considerable economic benefits in terms of school expenditure on ICT resources” (p. 101). To compare one-to-one and one-to-two classrooms, Larkin (2011) analyzed four seventh grade classes; one with one-to-one access five days per week, one with one-to-one access three days per week, one with one-to-two access five days per week, and one with one-to-two access three days per week. He used classroom observations, interviews, student forums, surveys, and data-logging software to analyze and compare data.

Larkin (2011) found that students with one-to-two access to laptops, both for three and five days per week, used laptops up to 30% longer than students with one-to-one access. He also noted that classes that used laptops only three days per week, both one-to-one and one-to-two, used the laptops more consistently. Larkin (2011) suggests that one-to-two access to laptops allows teachers and students to integrate technology more organically into teaching and learning practices, while one-to-one access changed the way teaching and learning took place.

According to FLDOE (2014a), digital learning pilots have a teaching and learning focus on the Florida Core Standards using Marzano instructional strategies and digital curriculum tools in order to graduate students college and career ready. The school district in which this study takes place lists seven pilot program schools at the elementary, middle, and high school levels, using five different operating systems as part of its digital pilot. The three elementary schools are using class sets of laptops or tablets/iPads while the four middle/high schools are providing each student with his or her own device. Towards the conclusion of the first year of implementation at the school district, the FLDOE (2014) reported positive results. Table 3 shows an increase in reading (two points) and math (12 points) benchmark assessment scores for 2013-2014 as compared to 2012-2013. Additionally, discipline data from the seven pilot program schools shows a decrease of 50% or more in level three and level four offenses, a 10% decrease in mobility rate, and a one percent increase in attendance rates (FLDOE, 2014a).

Table 3: Benchmark Score Comparisons for Pilot Program Schools

School	Reading Benchmark 2			Math Benchmark 2B		
	2012-2013	2013-2014	Change	End 2012-2013	YTD Feb 2014	Change
ES 1	54.3	58.0	3.7	45.2	58.2	13.0
ES 2	42.6	44.5	1.9	37.6	51.3	13.7
ES 3	66.4	68.2	1.8	52.3	60.8	8.5
MS 1	43.6	43.3	-0.3	44.7	42.0	-2.7
MS 2	64.4	68.0	3.6	46.1	67.3	21.2
MS 3	58.7	62.1	3.4	45.4	48.3	2.9
HS	39.0	37.3	-1.7	27.0	53.0	26.0
Average	52.7	54.5	1.8	42.6	54.4	11.8

Adapted from: Florida Department of Education. (2014). Orange County Public Schools: Digital learning pilot. Retrieved from http://www.fldoe.org/board/meetings/2014_02_18/orangepres.pdf

Table 4 shows the 2013-2014 budget and includes infrastructure costs, and projected costs for expanding the pilot program district wide. The largest expenditure is, not surprisingly, devices (nearly $7.8 million). However, instructional materials ($1.3 million) and professional development ($1.4 million) also require substantial funding. The projected cost for expanding the digital pilot program district wide is $229 million (FLDOE, 2012b).

Table 4: School District Pilot Program Schools Budget for 2013-2014

Expense Description	**Amount**
Project Management	$85,811
Technical Coordinators	$225,108
Professional Development	$1,372,132
Devices	$7,761,955
Instructional Materials	$1,342,263
Grand Total	$10,787,269

Adapted from: Florida Department of Education. (2014). Orange County Public Schools: Digital learning pilot. Retrieved from http://www.fldoe.org/board/meetings/2014_02_18/orangepres.pdf

The FLDOE (2012) has also established a six-year timeline for transitioning to digital instruction statewide from the 2010-2011 school year to the 2015-2016 school year. Table 2 shows the timeline that includes transitions in legislation, instructional materials, digital assessments, and common core standards. Beginning in the 2015-2016 school year all instructional materials purchased by school districts must be made available in digital format and at least 50% of the funding allocated to school districts must be used to purchase digital or electronic instructional materials (FLDOE, 2012). Additionally, by the 2015-2016 school year districts will be required to purchase instructional materials in mathematics, science, social studies, reading, and language arts; adopt digital assessments and implement common core standards in all grades k-12 (FLDOE, 2012).

With the impending transition to digital learning and the likely implementation of ubiquitous computing initiatives statewide, it is imperative to assess the success or failure of the initiatives in improving student achievement and graduating them college and career ready. The next section of this article focuses on what existing literature says about the effects of ubiquitous computing on student achievement.

Ubiquitous computing programs are described in the Florida Statutes as pilot program schools (Florida Statutes, 2013d) and the terms are used interchangeably throughout this study. Many variations of ubiquitous computing programs have been attempted since the 1990s. Therefore, this article will examine only ubiquitous computing programs that meet the following criteria established by Penuel (2006): (1) each student possesses a laptop computer equipped with productivity software; (2) students have wireless connectivity at school; (3) and the focus of the program is on using laptops for academic tasks.

The objective of the following sections is to identify patterns in existing literature regarding the impact of ubiquitous computing on student achievement. Student achievement can be more traditionally defined as evidence of student learning. However, this chapter will examine student achievement in multiple areas, including reading, mathematics, science, and social studies assessment data; 21st century skills acquisition; and motivation and engagement. The articles reviewed include qualitative and quantitative studies that describe the impact of ubiquitous computing programs and span a range of districts across the United States in both rural and urban school districts that include both traditionally high-achieving and traditionally low-achieving schools and students.

Academic Achievement

Ubiquitous computing programs have become increasingly popular in school districts across the United States. However, with tightening budgets nationwide and increased attention to accountability, school districts must be cautious when contemplating ubiquitous computing programs, as they are expensive to initiate and maintain. Rationales for implementing ubiquitous computing programs vary by district. However, six major objectives were cited in the literature by districts implementing ubiquitous computing programs: (1) eliminating computer labs; (2) improving academic achievement; (3) improving equity of access; (4) more effectively preparing students for the workforce; (5) transforming the quality of instruction; and (6) increasing economic benefits (Penuel, 2006; Topper & Lancaster, 2013). More recently, Ng (2015) separates the rationales into three categories: "(1) to support learning for the achievement of successful learning outcomes; (2) to develop twenty-first century skills as part of preparing students for the workplace and (3) to become responsible digital citizens and lifelong learners" (p. 5).

Several researchers have also indicated learning benefits derived from ubiquitous computing programs, including development of 21st century skills (Mouza, 2008; Rockman, 2003); increased active engagement; participation in groups; frequent interaction and feedback; and connection to real-world contexts (Mouza, 2008; Roschelle et al., 2000); improved writing skills (Mouza, 2008; Penuel, 2006; Russell, Bebell, & Higgins, 2004); improved attitude towards school (Mouza, 2008); and motivation and persistence in completing work (Mouza, 2008).

Dunleavy and Heinecke (2008) studied an urban middle school in an urban school district implementing ubiquitous computing. The school had an enrollment of 972 students of which nearly 60% were in poverty and over 87% were minority. The school was at risk of losing accreditation due to poor performance on standardized tests in previous years. The objective of the ubiquitous computing program was strictly to increase student scores on standardized assessments. No other changes were made to the curriculum or teaching pedagogies (Dunleavy & Heinecke, 2008). Only twelve teachers across grades six through eight and 300 of the school's students participated in the laptop program.

Dunleavy and Heinecke (2008) compared student standardized tests in math and science for students participating in the laptop program and students not participating in the laptop program for two consecutive years. The researchers also included previous assessment data for students as a covariate to equate the groups.

After accounting for pre-existing achievement scores, Dunleavy and Heinecke (2008) report three major findings: (1) the laptop program significantly affected student standardized test scores in science; (2) there was a significant interaction effect of treatment (the laptop program) and gender on science standardized test scores; and (3) the laptop program did not significantly affect student standardized test scores in math. To sum, the laptop program improved science test scores, especially for boys, but had no effect on math test scores. The results from Dunleavy and Heinecke's (2008) study raise two important questions regarding ubiquitous computing. (1) Does technology impact different content areas differently; and (2) does technology impact boys and girls differently?

Grimes and Warschauer (2008) studied the implementation of ubiquitous computing programs in three diverse California schools over two years. The schools included a largely Hispanic, low SES school, a largely Asian, high SES school, and a gifted program in a middle SES school. The researchers sought to analyze the effects of program implementation on teaching and learning in the schools, student and teacher perceptions of the programs, and the programs' impacts on student test scores. Grimes and Warschauer (2008) collected surveys, test records, and conducted observations and interviews to determine the effects of ubiquitous computing.

Grimes and Warschauer (2008) found that laptops were used daily in language arts, science, and social studies classes. However, they were not used regularly in math classes. The findings of this study suggests that a laptop program can have an important effect on facilitating the teaching and learning of writing, especially after the first-year adjustments" (Grimes & Warschauer, 2008, p. 314). Additionally, Grimes and Warschauer (2008) noted positive changes in the areas of information literacy, multimedia skills, and autonomy.

Grimes and Warschauer (2008) compared standardized test scores for students in the laptop programs and other students in the district not in laptop programs. The researchers analyzed California state tests in math and language arts to compare laptop and non-laptop student scores over two years. Laptop student language arts scores dropped 8.2 points during the first year and rose 8.9 points during the second year. Although the difference was significant from year to year, there was no significant difference over the two-year period. Math scores rose both years, but although the results were statistically significant, the effect size was low. Therefore, rise in scores cannot be attributed to laptops (Grimes and Warschauer, 2008).

Although the results from this study were inconclusive, Penuel (2006) suggests that student achievement scores may fall during the first year of implementation. Additionally, several researchers have found ubiquitous computing programs to have positive effects on student writing achievement (Gulek & Demirtas, 2005; Light et al., 2002; Lowther et al., 2001; Peckman, 2008; Penuel, 2006).

Gulek and Demirtas (2005) conducted a study at a predominantly white, affluent middle school in California. The school served a largely wealthy population of students and had historically been a high-achieving school. The middle school in this study did not provide students with laptops. Instead, parents were asked to purchase laptops for each student. In the case that a parent could not afford one, an application for a loaner computer was available. As of the date of the study, no student had been denied a loaner laptop. Students in the study were required to attend a computer camp where teachers explained the capabilities of the computers, assisted students in installing software necessary for class, and explained the usage policies during school. About one-third of students in the school enrolled in the laptop program and the population was comparable to the general school population.

By comparing laptop and non-laptop students, Gulek and Demirtas (2005) studied the effects of ubiquitous computing on student achievement data, including grade point averages (GPAs), end of course (EOC) exam grades, district writing assessments, and standardized test results. Student achievement data was then averaged by grade level to compare laptop and non-laptop students.

The results of student achievement data were conclusively in favor of laptop students. Sixth grade students who used laptops earned an average of 3.50 GPA while non-laptop users averaged 3.13, seventh graders averaged a 3.28 GPA for laptop users and 2.94 for non-laptop users, and eighth graders averaged a 3.23 GPA for laptop users and 3.07 for non-laptop users (Gulek & Demirtas, 2005). Like student GPAs, student EOC grades, district writing assessments, and standardized test results were substantially better for laptop students than for non-laptop students. Students in the laptop program not only outperformed non-laptop students from the same school in the district writing assessment, they also outperformed the district average. In norm-referenced and standardized tests in language and math, not only did laptop students outperform non-laptop students, but also substantially outperformed the national average (Gulek & Demirtas, 2005).

Lee, Waxman, Wu, Michko, and Lin (2011) sought to find the relationship between teaching with technology and student learning in k-12 settings. To analyze the relationship between teaching with technology and student learning outcomes Lee et al. (2011) conducted a meta-analysis of experimental and quasi-experimental studies between 1997 and 2011. They calculated a total of 366 effect sizes from 58 studies and concluded a weighted mean effect size of .42.

Lee et al. (2011) found a moderate relationship between teaching with technology and student learning. In addition, they outlined several categorical moderators that have the potential to impact decisions about technology in the classroom. Lee et al. (2011) found that teaching with technology had the least impact on high school (9-12) student achievement with a mean effect size of .22, but had a moderate impact on k-3 students with a mean effect size of .5, and nearly a high effect size of seventh and eighth grade students with a mean effect size of .59.

In addition to grade level, two additional categories are of significance regarding teaching with technology and student learning; use of technology and student to computer ratio. Students' use of technology plays an important role in determining the effects of technology on student learning. Effect sizes are greater for students who use technology for remediation of skills not learned (.83), writing (.59), and project-based learning (1.39) than for students who use technology for problem-solving (.39) or multiple objectives (.19) (Lee et al., 2011). Student to computer ratio also has a substantial influence on the impact of technology on student learning. Classrooms with a one-to-one ratio of students to computers had a mean effect size of .40, while classrooms with two students per computer and three to five students per computer had mean effect sizes of .65 and 1.08 respectively (Lee et al., 2011). These results are especially interesting in a time when ubiquitous computing is becoming common in districts across the nation and state legislatures (i.e. Florida) are requiring educational spending to increasingly fall to technology.

Liao, Chang, and Chen (2008) compared the effects of instruction using technology versus traditional instruction on elementary school student achievement in Taiwan. They conducted a meta-analysis of studies that compared computer assisted instruction to traditional instruction and analyzed student achievement through a standardized assessment. Liao, Chang, and Chen (2008) analyzed 48 studies between 1990 and 2003 and found overwhelmingly in favor of computer assisted instruction (44 of the 48 studies favored computer assisted instruction).

The mean effect size of computer assisted instruction on Taiwanese elementary student achievement was .45 overall but differed by subject area. While the overall effect size of technology on student achievement was moderate (.45), reading and language arts (.70) was relatively high, while social studies (.39) was near the mean, and mathematics (.32) and science (.31) were relatively low (Liao, Chang, & Chen, 2008).

Tamim, Bernard, Borokhovski, Abrami, and Schmid (2011) conducted a second-order meta-analysis to compare student achievement in all subjects and grade levels including postsecondary education, between technology-enhanced classrooms and classrooms that employed traditional instruction. Tamim et al. (2011) analyzed 25 different meta-analyses of over 1,000 studies that included nearly 110,000 students between 1985 and 2011. They noted an overall effect size of .35. However, like Lee et al. (2011), Tamim et al. (2011) found differences based on student grade level. The effect size for technology use in k-12 was calculated at .40 but only at .29 for postsecondary education. Additionally, similar to Liao, Chang, and Chen (2008), Tamim et al. (2011) found that the purpose of technology use also impacts student achievement. When used for direct instruction, technology's impact on student learning had an effect size of .31. However, when used to support instruction, technology's impact on student learning increased to an effect size of .42. The results of the studies described above raise poignant questions regarding digital learning; how are the effects of technology on student achievement helped or hindered by different subject areas, grade levels, and uses? What other variables impact teaching and learning with technology? How does this information impact state policies and district level decision-making?

Table 5: Summary of Student Achievement Effect Sizes by Meta-Analysis

Authors	Year Span	Subject Area	Effect Size
Lee et al.	1997-2011	Student Achievement	.42
Liao, Chang, & Chen	1990-2003	Student Achievement	.45
Tamim et al.	1985-2011	Student Achievement	.40 (k-12 only)

Shapely, Sheehan, Maloney, and Caranikas-Walker (2011) compared 21 technology immersion middle schools to 21 comparatively matched schools. Shapely et al. (2011) used surveys; school discipline and attendance; and academic achievement to measure the effects of technology immersion. The surveys were used to measure students' technology proficiency, classroom activities, and small group work. Student academic achievement was measured using Texas' state standardized assessment, the TAKS. The researchers found no statistically significant difference between the digital immersion schools and the comparison schools on reading or mathematics standardized assessments. "The effect of technology immersion on students' reading or mathematics achievement was not statistically significant, but the direction of predicted effects was consistently positive and was replicated across student cohorts" (Shapely et al., p. 311, 2011).

Rosen and Beck-Hill (2012) used a mixed-method approach which included student standardized assessments, classroom observations, student questionnaires, and school discipline and attendance records to determine the impact of one-to-one initiatives on student achievement and other non-academic outcomes. Data was collected from fourth and fifth grade classes at four different elementary schools at the beginning and end of the school year.

Rosen and Beck-Hill (2012) found that fourth and fifth grade students in the experimental (laptop) group significantly outperformed their matched counterparts in reading and mathematics standardized assessments after the year-long program. In addition to the increased academic achievement, the study found that student attendance was better for the experimental group, and discipline referrals were greatly reduced from the previous year. Additionally, students in the experimental group reported greater motivation to learn reading and mathematics than did students in the control group.

Kposowa and Valdez (2013) conducted a study to determine the effects of student laptop use on their scores on standardized tests. This study was conducted at an elementary school in California. The student population consisted of less minority students, a higher household income than, and a higher rate of educational attainment than the state and national average. However, 76% of students at the school qualified for free or reduced lunch and 44% of the students were classified as English language learners (ELLs), both greater than the state average. Finally, "Per capita spending per pupil in the Palm Springs Unified School District as a whole was $7,639 in 2007-2008, compared with the statewide average of $10,805" (Kposowa & Valdez, 2013, p. 354). Data were collected from surveys existing student records.

Surveys identified the most frequent uses for laptops as reported by students as browsing internet at home (37.78%), writing papers at home (24.45%), and playing games at home (22.22%). Surveys also revealed improved student attitudes about school, including that assignments have been more interesting and that their organization has been better since receiving laptops. A review of student standardized test scores revealed a statistically significant difference in student scores in English/Language Arts and Mathematics between students with laptops and those without, with students with laptops scoring significantly higher. "Results of data analyses show evidence to suggest that provision of 24/7 laptops to students contributes significantly to achievement as measured by standardized scores" (Kposowa & Valdez, 2013, p. 372).

Ornits and Yael (2012) studied the effects of one-to-one laptop learning on student performance on a higher-level language arts task. The study examined 181 7th and 9th grade students from two schools comprised predominantly of families with high SES backgrounds and found there was a statistically significant difference between students in the comparison group and students in the control group. Students using one-to-one laptop instruction scored an average of 82.5% on the assigned task compared to only 73.25% for the control group.

Finally, Kobelsky, Larosiliere, and Plummer (2013) investigated the "relation between changes in how IT is used and changes in performance on standardized tests at over 6000 schools in the K-12 educational sector over two time horizons: from 2007 to 2008, and 2007 to 2011" (p. 49). Data were gathered from three different sources from the Texas Education Agency (TEA). The first source of data is teacher surveys from grades 3, 8, and 11for the years 2007 through 2011. The second source is from the Texas Education Agency (TEA) financial, teacher, and student data for each school. The final source of data is from the Texas Assessment of Knowledge and Skills (TAKS) scores for reading and mathematics.

The researchers found that the results of the study differed by time horizon. "Short-term (year-over-year) changes in usage have no effect in any grade, while long-term (four-year) changes toward an informating/transforming type of usage are related to improvements in performance, indicating that teacher user experience has a moderating effect" (Kobelsky, Larosiliere, & Plummer, 2013, p. 50). These effects are present in elementary and middle school, but not high school students.

Data from 2007-2011 support the first hypothesis that IT usage is positively associated with performance in elementary and middle school, but not in high school. "This change in IT usage does not help marginal reading students suggesting the improvement in reading scores occurs for students who already meet minimum reading standards. The change does help marginal math students, so that 1.29% more meets the minimum proficiency level in math" (Kobelsky, Larosiliere, & Plummer, 2013, p. 57).

> In contrast to the findings for elementary schools, it appears that a change in IT usage in middle school is more salient for marginal reading students. For mathematics, a one unit

change in IT usage focus leads to a 2.5 point increase in mean school score. (Kobelsky, Larosiliere, & Plummer, 2013, p. 57)

Kobelsky, Larosiliere, and Plummer also found that the longer teachers have implemented IT in their classrooms, the more effective the IT is at improving student achievement. "A teacher's level of experience with IT plays a central role in evaluating the effect of Constructivist/Collaborative IT usage on school performance" (Kobelsky, Larosiliere, & Plummer, 2013, p. 58).

Reading and Writing Achievement Using One-to-One Computing

The previous section reviewed analyses of the impact of digital tools on student achievement in no specific subject matter. This section narrows the scope of the review to the impact of technology on student achievement in reading. Moran, Ferdig, Pearson, Wardrop, and Blomeyer (2008) analyzed the impact of technology on advanced reading skills (i.e. comprehension, metacognition, strategy use, and motivation and engagement) in middle school (grades 6-8) students. Moran et al. (2008) analyzed 20 studies between 1988 and 2005 from around the world. The results of the study address the only skill reported by the assessments used, comprehension.

Moran et al. (2008) found technology implementation to have an effect size of .49 on student achievement in reading. Additionally, they also found three other relevant correlations. First, the longer the study, the lower the effect size. The effect size for studies lasting two to four weeks was .54 while the effect size for studies lasting five or more weeks was only .34. Second, effect size was higher for general education students (.52) than for others (.28). Finally, researcher-developed technologies were found to be substantially more effective (1.20) than commercial technology (.28) (Moran et al., 2008).

Cheung and Slavin (2013a) analyzed the impact of technology on reading achievement for struggling elementary school students. They included 20 studies between 1980 and 2012 of about 7,000 first through sixth grade students. Cheung and Slavin (2013a) found a low weighted effect size of .08. However, once again the effect size differed by grade level grouping. Technology had an effect size of .36 on first to third grade student reading achievement and only .07 on fourth through sixth grade student achievement. In comparison to the previous findings of the impact of technology on student achievement, Cheung and Slavin's (2013a) results seem to be an outlier. However, it should be noted that this study analyzed the impact of technology on struggling readers, another subgroup. These findings in addition to the findings of Moran et al. (208) raise more questions about which variables impact learning with technology. How do student abilities or disabilities impact the effects of learning with technology?

Similarly to Cheung and Slavin (2013a), Zucker, Moody, and McKenna (2009) analyzed seven experimental and eleven quasi-experimental studies to determine the effects of e-books on reading achievement of emergent readers and students with reading disabilities in PK-5. An e-book is "a text presented on a computer with an oral reading option (also known as text-to-speech) and some form of hypermedia (i.e., embedded images, sounds, video, animation, and so on)" (Zucker, Moody, & McKenna, 2009, pp. 49-50). Zucker, Moody, and McKenna (2009) found a weighted effect size of .31 for studies that assessed student comprehension as a result of digital technology (e-books).

Table 6: Summary of Student Achievement Effect Sizes in Reading

Authors	Year Span	Subject Area	Effect Size
Moran et al.	1988-2005	Reading Achievement	.49
Cheung & Slavin	1980-2012	Reading Achievement	.08
Zucker, Moody, & McKenna	1997-2007	Reading Achievement	.31

Mathematics Achievement Using One-to-One Computing

Cheung and Slavin (2013b) compare education technology applications to traditional teaching methods in their ability to improve student achievement in mathematics. The study analyses 74 studies that include nearly 57,000 k-12 students between 1980 and 2012. Cheung and Slavin (2013b) calculated the overall weighted effect size for this study to be .16, positive but small. Of interest is their finding of effect size reports by decade. One would assume that more recent implementations of technology would yield greater effect sizes as teachers and students become more familiar with technology and research illustrates best practices. However, Cheung and Slavin's (2013b) meta-analysis found the opposite to be true. The mean effect size for digital learning was .23 in the 1980s, .15 in the 1990s, and .12 in the 2000s. Although these results are indicative of only the 74 studies included by Cheung and Slavin (2013b), they raise questions about teaching and learning with technology.

Li and Ma (2010) examine the impact of technology on student achievement in mathematics in k-12 classrooms. They sought to determine the impact of computer technology on mathematics achievement as compared to traditional instruction, and to identify features that moderate the effects of computer technology on student learning. Li and Ma (2010) analyzed 46 studies published between 1990 and 2006 containing nearly 37,000 students. The effect size of computer technology on student learning was calculated at .28, a moderate effect. However, technology was strongly more effective in promoting mathematics achievement when used to help special need students (1.51) than to help general education students (.61). Technology was also more effective in promoting student learning in low socioeconomic status (SES) students (1.03) than middle SES students (.58). Additionally, Li and Ma (2010) found that elementary students (.78) performed better than secondary students (.61); articles published before 1999 listed higher effect sizes (.99) than articles published after and including 1999 (.42); and that long term interventions of one year or more listed lower effect sizes (.55) than short term interventions lasting only one term (.88). These findings are consistent with others listed above, but add another question; is there an interaction effect between variables that impact use of technology on student achievement?

Table 7: Summary of Student Achievement Effect Sizes in Mathematics

Authors	Year Span	Subject Area	Effect Size
Cheung & Slavin	1980-2012	Mathematics Achievement	.16
Li & Ma	1990-2006	Mathematics Achievement	.28

Other Educational Outcomes Using One-to-One Computing

Attitude, Motivation, and Persistence

In addition to improving student test scores, several studies have pointed to improved school attitude, motivation, and persistence in work completion as benefits of ubiquitous computing. Mouza (2008) studied an urban school district in New York City (NYC) Employing Microsoft's Anytime, Anywhere, Learning Program. The study focused on one elementary school (grades k-5) serving 94% Hispanic students who qualified for free or reduced lunch. Three classrooms participated in the study; a third grade classroom, a fourth grade classroom, and a fifth grade classroom. Data was collected from classroom observations, teacher interviews, student questionnaires, and student focus groups. Although students were allowed to take the laptops home, they did not have Internet access at school. However, the results of this study are still relevant to contemporary ubiquitous computing programs that are networked at school because it does not look at standardized test scores. Instead, this study focuses on student attitudes, motivation, and persistence.

As a result of the ubiquitous laptop program, Mouza (2008) found that teachers and students used laptops differently in their classrooms for learning. "Technology was used as part of a model that emphasized project-based learning and construction of knowledge rather than recitation or drill and practice" (Mouza, 2008, p. 455). Additionally, Mouza (2008) reports four major findings from the comparison of laptop and non-laptop classes; (1) fourth graders who had laptops reported significantly better attitudes toward school than fourth graders who did not have laptops; (2) students who had laptops demonstrated more motivation and persistence in completing work than students who did not have laptops; (3) students in laptop classes had more interactions with teachers and peers, frequently trading skills, sharing tips, and serving as peer tutors, (4) and students in laptop classes showed greater gains in writing and mathematics.

Gurung & Rutledge (2014) studied student engagement with technology for personal and educational purposes. This study presents a "phenomenological study that examines the intersections of personal and academic uses of technology by some digital learners across home and school settings" (Gurung & Rutledge, 2014, p. 92). The study was conducted at a public alternative high schools serving 183 students of which 80% were either Hispanic or Black. Over 70% of students received free or reduced lunch. Data \gathered from interviews and field notes revealed "There was an overlap between the participants' personal digital engagement (PDE) and educational digital engagement (EDE). Their digital habits, interests, and aptitudes functioned as the linking components between PDE and EDE" (Gurung & Rutledge, 2014, p. 99). This suggests that students do not perceive a strict line between personal and educational uses of technology, and they believe that "such boundary blurring [i.e. listening to music to block out noise from peers] actually help them stay focused in their study" (Gurung & Rutledge, 2014, p. 99).

Oliver and Corn (2008) examine the "differences in student technology use and skill at a private middle school as observed by researchers and discussed by students over two years: the baseline year prior to implementing a new 1:1 tablet computing program and the first year of implementation" (Oliver & Corn, 2008, p. 216).

Survey and interview findings showed a statistically significant increase in student satisfaction with the school technology infrastructure; "However, only students at the 6th grade level in year one reported significantly higher satisfaction with how their teachers were using technology in the classroom" (Oliver & Corn, 2008, p. 220). Teacher behaviors differed from the baseline year (before one-to-one computer implementation) to the first year of implementation. Year one of implementation included an increase in individual tutoring, project-based learning, and teachers acting as coacher. However, higher-level questioning was slightly lower, and higher-level feedback was substantially lower during year one of implementation.

Impact on Classroom Practices

Lowther, Ross, and Morrison (2003) examined the effects of providing fifth, sixth, and seventh grade students ubiquitous access to laptop computers. The researchers focused on the impact of laptops on classroom activities, student use of technology, and student writing and problem-solving skills (Lowther, Ross, and Morrison, 2003). The study compared five laptop classes and five non-laptop classes through "50 one-hour systematic classroom observations of both basic pedagogy and technology usage, a district-administered writing sample, student surveys and focus groups, a teacher survey and interview, and a parent survey and interview" (Lowther, Ross, and Morrison, 2003, p. 25).

Lowther, Ross, and Morrison (2003) found that teaching was different in laptop compared to non-laptop classes. The laptop classes used more student-centered strategies, "such as project-based learning, independent inquiry, teacher as coach, and cooperative learning" (p. 41). Additionally, laptop students in this study demonstrated "better computer skills, and more extensive use of computer applications for research, production, writing, and design" (Lowther, Ross, and Morrison, 2003, p. 25). Students in the laptop classes demonstrated higher levels of interest and engagement and also performed better in both the district writing assessment and the problem-solving test than students in the non-laptop classes (Lowther, Ross, and Morrison, 2003). To sum, Lowther, Ross, and Morrison (2003) found that ubiquitous computing in middle grades classes improved teacher and student classroom practices, enhanced student use of technology for academic purposes, and improved student achievement in writing and problem-solving.

Russell, Bebell, and Higgins (2004) studied an affluent suburban elementary school near Boston. The researchers studied fourth and fifth grade classrooms over a period of two years. The district funded laptop carts for students to share class sets one week at a time. However, the principal of the school in this study initiated an optional purchase program for parents. Enough students participated in the study to eventually fill two fourth-grade and two fifth-grade classrooms.

Russell, Bebell, and Higgins (2004) examined differences in instructional practices and student learning activities. The researchers collected data from student surveys, teacher interviews, classroom observations, and a student drawing prompt. Russell, Bebell, and Higgins (2004) identified five primary findings. As expected, technology was used considerably more often in the one-to-one classes than in the classes with shared laptops. Student engagement was also higher in the one-to-one classes than the classes with shared laptops. Students in the one-to-one classes were not only on-task more often, but were also more willing to participate in class activities. Another finding from this study is that computers were the primary writing tools for student in one-to-one classes and those students were observed writing more frequently than students from the shared laptop classes.

The next finding from the study was that classroom structure was different for classes with one-to-one laptops compared to classes with shared laptop carts. The one-to-one classes spent the majority of classroom time independently working, while the shared computer classes spent the majority of their time on whole group instruction (Russell, Bebell, & Higgins, 2004).

The last finding from the study was that one-to-one students used laptops at home more frequently in general, and also more frequently for school assignments, than students from the shared laptop cart classes.

Lowther et al. (2012) investigate the effectiveness of a Michigan ubiquitous computing program on teaching practices and student learning. The researchers gathered data from 90 participating schools to determine the program's effectiveness on improving student 21st century knowledge skills and academic performance. "Generally, 21st century skills are identified as information and communication skills, thinking and problem-solving skills, and interpersonal and self-directional skills" (Mouza, 2008, p.448). Data was collected from classroom observations, teacher questionnaires, student surveys, and state achievement scores.

Lowther et al. (2012) found that, while moderate, the results of the ubiquitous computing initiative in Michigan showed increases in the use of student-centered teaching strategies, student attitudes and motivation, amount of laptop use, and acquisition of 21st century skills. Student achievement data was inconclusive as some schools implementing ubiquitous laptop programs outperformed their comparison schools while the reverse was true for others.

Li and Pow (2011) studied the effects of technology affordance on a government-aided elementary school in Hong Kong. Technology affordance is "a term used to describe opportunities provided for users in a technology-supported learning environment" (Li & Pow, 2011, p. 320). The study included four classes, two equipped with a tablet-PC for each student to take home and two using traditional instruction without tablet-PCs. All four classes implemented the same curriculum. The only intervention was providing students the tablet-PCs to use in school and at home. Teachers and students did not receive any professional development or instruction on the Tablet-PCs or digital instruction.

Students in this study were asked to log their learning experiences three times per week for five weeks. Students logged the amount of time they spent on IT-related cognitive activities, both leisure and learning. The logs showed Tablet-PC classes outscored non Tablet-PC classes in "IT-supported cognitive activities such as searching for information, reading information, organizing information, analyzing data, writing, peer tutoring, sharing learning resources and online discussion" (Li & Pow, 2011, p.322). However, there was no difference between the Tablet-PC and the non Tablet-PC classes in IT-supported leisure activities. In short, students in the Tablet-PC classes used IT to support their learning more often, and perceived IT as enhancing their learning motivation, abilities, and strategies more often than students from non-Tablet-PC classes, but did not use technology more often for leisure (Li & Pow, 2011).

Li and Pow (2011) draw several conclusions from their study on technology affordance. They conclude that ubiquitous technology infusion enhances both formal and informal learning, at school and at home; that it can have a direct impact on student learning if students are provided with the necessary skills; and that it can provide "seamless learning spaces that can break the boundary between formal and informal learning" (Li & Pow, 2011, p. 325).

One-to-one initiatives have also been studied to determine their relationship with other academic areas such as homework. Medicino, Razzaq, & Heffernan (2009) studied the effects a mathematics digital tool on student learning during homework assignments. The study consisted of 92 students from four fifth grade classes, 54 of which had internet access at home. Students in the web-based homework group and the paper-and-pencil homework group were assigned two homework sets; one consisting of number sense questions and the other consisting of mixed questions. The homework assignments were identical for both groups. The web-based homework group received interactive scaffolding and hints on demand from the program. Pre- and post-tests were conducted on both groups to determine student learning.

Although learning took place for both the web-based homework group and the paper-and-pencil homework group, there was a statistically significant difference in favor of the web-based homework group when comparing both groups. A paired samples t-test showed an effect size of .61. “The mean gain for the Web-based homework group was 2.32 points out of 10 points, and for the paper-and-pencil homework group the gain was 1.14 points out of 10 points” (Medicino et al., 2009, p. 342). The findings of this study provide an alternative for teachers who teach in traditional settings without the benefit of one-to-one laptops.

Dunleavy, Dexter, and Heinecke (2007) sought to examine the ways in which middle schools teachers used one-to-one laptops in their classrooms. The study used a multiple case study design. Eight teachers from mathematics, science, and language arts were selected from two different middle schools. Observation, interview, and document data were collected from teachers, students, and administrators. High achieving teachers and students were selected for the case study.

Dunleavy, Dexter, and Heinecke (2007) found that the most frequent use of laptops in the observed classrooms was for online research purposes alongside productivity tools. “Overall, the use of the 1:1 laptops appeared to contribute generally to the effectiveness of the learning environments per the design criteria of being more learner-, assessment-, community- and knowledge-centered” (Dunleavy, Dexter, & Heinecke, 2007, P. 444).

The second most frequent use of laptops in the observed classrooms was for drill and practice. Although there were instances of low-level drill and practice, the majority of the activities were considered higher-level thinking drills and practice (Dunleavy, Dexter, & Heinecke, 2007).

> The 1:1 student to networked laptop ratio in this drill and practice example provided added value in five main ways: (i) an increased ability to formatively assess; (ii) an increased ability to individualize instruction and pacing; (iii) an increased ability to provide timely feedback; (iv) an increase in the student interaction and collaboration; and (v) an increase in student engagement. (Dunleavy, Dexter, & Heinecke, 2007, P. 446)

Warschauer (2008) examined the relationship of laptop use to student literacy practices at 10 urban and suburban schools in California and Maine. Data were gathered from a combination of observations, interviews, surveys, and document reviews.

One major finding of the study was the way one-to-one computer instruction changed the teaching and learning of reading. First, the "study found that the introduction of one-to-one laptop programs greatly expanded the teachers' opportunities for scaffolding texts" (Warschauer, 2008, p. 56). In addition to better scaffolding, the study found an increase in epistemic engagement. "Epistemic or knowledge-building literacy activities have students working together to interpret and create meaning from texts" (Warschauer, 2008, p. 56). The ubiquitous access to laptops provided more opportunities for students to engage in epistemic activities, and teachers were observed to take advantage of these opportunities with frequency. Finally the study found that one-to-one laptop access led to greater text-to-screen time; in other words, students read online texts more frequently than they read paper texts.

One-to-one laptop access was also observed to permeate writing instruction. Student writing was observed to improve student stamina in writing, increased ease in the revising and editing stages, and increased amount and quality of publication of student work.

Inan and Lowther (2012) used path analysis to determine the relationships between several factors affecting teacher implementation of one-to-one computers. Data were gathered from 379 teachers from 76 diverse Michigan schools. The researchers found that teacher beliefs and readiness, along with several school-level factors directly and indirectly affect teacher technology implementation.

> Teacher beliefs and readiness directly influence teachers' laptop integration. School-level factors (overall support for school technology, technical support, and professional development) indirectly influence teachers' laptop integration. School-level factors (overall support for school technology, technical support, and professional development) positively influence teacher beliefs and teacher readiness. Teacher beliefs and readiness mediated the indirect effects of school-level factors on teachers' laptop integration. (Inan & Lowther, 2010, p. 941)

Lei (2010) studied the differences between quality and quantity of technology use on student achievement. "This study investigates the relationship between technology use and student outcomes by comparing the association between the quantity of technology and student outcomes with the association between the quality of technology use and student outcomes" (Lei, 2010, p. 458).

Student time spent on computers every day explained 3.1% of the total variation in student outcomes. Thus, time spent on computers had no statistically significant effect on student GPA, technology proficiency, learning habits, or developmental outcomes. "Regression analyses were conducted to examine if students' outcomes were affected by the five types of technology uses: general technology use, subject-specific technology use, social-communication technology use, construction technology use and entertainment/exploration technology use" (Lei, 2010, p. 463).

The quality of technology used yielded different results. Student use of technology for social-communication purposes had a positive, yet not statistically significant, effect on student GPA. However, the study did find social-communication usage had an effect size of .21 on student GPA. Inversely, student use of technology for entertainment-exploration was found to have a statistically significant negative effect on student GPA. Different uses of technology had differing effects on student outcomes. "General technology uses were positively associated with student technology proficiency, but the influence on other outcomes was minimal" (Lei, 2010, p. 466).

Maninger and Holden (2009) examined quantitative and qualitative data from one-to-one initiatives in grades five through eight of a private K-8 school to determine their effects on teaching and learning. Teacher interviews, classroom observations, and student surveys were used to gather and analyze data.

Classroom observations noted the frequency of different types of technology uses. In a 55-minute class period, students spent the most time working alone (M = 21.18), working in small groups (M = 10.00), and in whole class instruction (M = 26.18). Students spent about 7 minutes off-task (M = 6.76) during a class period. Teachers spent the most time directing the whole group (M = 32.35), facilitating/coaching (M = 22.65), and interactive whole group (M = 16.47).

"The first major theme to emerge from the interview data was "Engaging and accommodating," or how the teacher-participants' acknowledged an increase in their students' classroom collaboration as a result of the one-to-one initiative" (Maninger & Holden, 2009, p. 13). The second major theme identified in the interviews was increased access. "The teacher-participants commented that over a short period of time their students were able to access significantly more information and were exposed to more modes of communication via computer technology than the teachers could ever have provided on their own" (Maninger & Holden, 2009, p. 13-14).

School District Implementation Practices

Although student achievement is the ultimate objective of any academic intervention, such as ubiquitous computing, implementation practices can go a long way in determining the success or failure of a school district's initiative. To begin with the conclusion, "Programs that examined the needs of their student and teacher populations, developed technology infrastructure, and sought support from stakeholders were more successful; the program[s] that [rely] on technology alone to produce outcomes ultimately [fail]" (Warschauer et al., 2014, p. 58).

Warschauer et al. (2014) examined three school districts that implemented ubiquitous laptop programs in which each student received a laptop computer. The school districts examined—Birmingham, Littleton, and Saugus—varied in student demographics, district funding, program objectives, and implementation approach.

The Birmingham school district implemented the One Laptop Per Child (OLPC) program, which emphasized student autonomy and ignored teacher training and curriculum changes appropriate for the new technology, much like the study conducted by Li and Pow (2011). The Littleton and Saugus districts implemented a more integrative approach that included extensive teacher training, improved infrastructure, and a targeted curriculum (Warschauer et al., 2014). The Birmingham district consists of over 95% African American students of which over 80% are on free or reduced lunch. On the other hand, the Littleton and Saugus districts consist of predominantly White and higher SES students.

Not surprisingly, the Birmingham initiative failed and was discontinued the following year while the Littleton and Saugus districts found success and expanded their programs. Students in the Littleton and Saugus districts expressed using the laptops more frequently and for specific educational purposes, particularly drafting, revising, editing, and publishing writing. Students in Birmingham reported using the laptops very little in school and for few educational purposes. The most frequently used applications in the Birmingham district were the chat feature and the camera feature. Students in the Saugus district made greater overall English Language Arts (ELA) gains after the laptops than before. Likewise, in Littleton Hispanic and low-income students made significant gains (Warschauer et al., 2014).

From this study, it is not possible to identify which factors influenced, or to what degree, the success or failure of the school districts. It would be easy to conclude that the Birmingham school district planned poorly and failed as a result. However, the Birmingham school district faced different challenges than the other two districts, including funding. It is possible that the Birmingham school district did not have the funds to train teachers extensively, hire technicians, update school infrastructures, or reform the curriculum. Still, the results of this study suggest that the aspects mentioned above are essential to the success of a ubiquitous computing program. Therefore, districts intending to adopt ubiquitous computing programs must make provisions that include funding for not just the hardware, but also the infrastructure and training that accompanies it.

Like Warschauer et al. (2014), Topper and Lancaster (2013) studied five school districts in the Midwest implementing ubiquitous computing programs from 2009 to 2011. The objective of their study, however, was only to note common themes and experiences across the districts. Topper and Lancaster (2013) used semi-structured interviews with school and district leaders; stakeholder surveys; and case studies of the five school districts to identify successful implementation practices. The results are broken down into four themes, (1) funding; (2) teacher professional development; (3) expectations for benefits; and (4) formal evaluation plans.

With regards to funding, the five school districts used bonds; Title I and Title II money; and private donor funding to purchase the technology equipment. In the area of teacher professional development, the five districts differed. The most common form of support provided to teachers across the districts was a trainer on-site. Two districts also offered workshops and focused teacher groups, and one district collaborated with the education faculty at a nearby university. Surprisingly, only one school district cited improved student achievement on standardized test scores as an expected benefit from its ubiquitous computing program. The other districts cited “improved access to technology, preparation for life after school, and elimination of computer labs" (Topper & Lancaster, 2013, p. 352). Only two school districts had formal evaluation plans in place for their ubiquitous computing programs. The other three districts either had an informal process or no process at all. The evaluation plans for the two districts with formal plans in place included "measurements of the impact of the initiative on the knowledge, skill, attitudes and actions of staff, changes in classroom instruction, and impact on students' experiences and academic achievements" (Topper & Lancaster, 2013, p.352).

Topper and Lancaster (2013) drew several conclusions from their study in addition to the pre-identified implementation themes:

> Participants in this study indicated that adopting a 1:1 initiative might actually cost more, not less, over a five-year time frame because of expenditures related to maintenance, support, and insurance, among other costs. Beyond the initial expenditures on equipment, software, infrastructure, and training/support, costs associated with textbooks (digital copyrights, access, etc.) and maintenance and repair can represent a significant portion of a district's yearly budget. (p. 353)

Additionally, Topper and Lancaster (2013) conclude that one-time funding such as donations can present additional challenges due to future costs like replacing hardware and increasing infrastructure.

> To achieve this change, a school system must go through major processes. It requires setting new educational objectives, preparing new curricula, developing digital instructional material aligned with learning standards, designing a new teaching and learning environment, training teachers, creating a school climate that is conducive to educational technology, and so on. Innovative approaches in learning science,

> technology, and assessment, combined with professional development for teachers, can provide a foundation for new and better ways to enhance students' knowledge and skills. (Rosen & Beck-Hill, 2012, p. 226)

Drawbacks

It is generally believed that increasing student access to technology, as is the case with ubiquitous computing programs, leads to increased student engagement and motivation. However, Donovan, Green, and Hartley (2010) point out that "the introduction of technology into classrooms introduces a number of other variables that impact student engagement. Student learning needs, behaviors, and classroom roles and relationships all change in a technology-rich environment" (p. 424). Thus, Donovan, Green, and Hartley (2010) explore the relationship between different classroom configurations and student off-task behavior.

The study took place during the first year of a ubiquitous computing program implementation at a largely Hispanic, low-income middle school. Specifically, Donovan, Green, and Hartley (2010) studied 12 seventh grade classes in the school and analyzed teacher actions, teacher/student interactions, student uses of laptops, and teacher uses of laptops. To analyze student engagement, Donovan, Green, and Hartley (2010) identified three different configurations. Configuration A represents the use of laptops pervasively throughout the class. Students used the laptops responsibly and as the main instructional tool. Assignments were accessed, completed, and submitted digitally, and the laptops were used for various instructional purposes including research (Donovan, Green, and Hartley, 2010). Configuration B represents classrooms in which not all students brought their laptops for several reasons and students did not always use laptops responsibly, often waiting to be asked to use them or using them to play games or other personal reasons. Students in Configuration B were grouped by laptop accessibility and assignments were primarily distributed in paper form rather than digitally. The laptops in this configuration were only used for basic functions and not as a primary instructional tool. Configuration C represents classrooms in which most students did not bring their laptops and laptops were rarely used. Teachers operated as though students did not have laptops.

Using the three classroom configurations described above, Donovan, Green, and Hartley (2010) collected data on student off-task behavior through classroom observations. The results of this study differ from generally accepted views on the relationship between access to technology and student engagement. Donovan, Green, and Hartley (2010) found that off-task behavior was more pervasive in Configuration B than in A and C, suggesting that access to technology does not have a linear relationship with student engagement. Although Configuration B exhibited a larger degree of off-task behavior, Configuration A actually exhibited more frequent off-task behavior. However, the off-task behavior did not affect student achievement in configuration A while it did affect student achievement in Configurations B and C. Donovan, Green, and Hartley (2010) explained that student achievement in Configuration A was not affected because students completed assignments on their own time, while in Configurations B and C students did not complete assignments despite being redirected immediately. To sum, Donovan, Green, and Hartley (2010) found that increased access to technology does not increase student engagement, but does improve student achievement despite off-task behavior. Dunleavy, Dexter, and Heinecke (2007) also found in their study that networked laptops were found to detract from effective learning as they exacerbated student distractions.

Additional drawbacks are discussed in other studies. "The challenges [of one-to-one classrooms] fall generally into two categories: (i) classroom management; and (ii) hardware issues" (Dunleavy, Dexter, & Heinecke, 2007, P. 449). According to Dunleavy, Dexter, and Heinecke (2007), teachers reported classroom management as becoming more of a problem with the presence of networked computers as computers became an additional distraction. Additionally, hardware issues created another layer of distractions as students would often leave their computers at home, run out of battery, or have their computers under repair.

Likewise, Warschauer (2008) found that "Although laptop programs were broadly viewed as beneficial for student learning, they did not result in higher test scores" (p. 63). More importantly, laptop programs in this study did not reduce the achievement gap. "Low SES students and the schools that served them were often less prepared to take advantage of the full capability of laptops due to students' limited literacy skills and lack of prior experience on working with computers" (Warschauer, 2008, p. 64). Finally, studies have also found that "Insufficient professional development of teachers has been an escalating concern for all technology integration initiatives and projects" (Inan & Lowther, 2010, p. 938).

Conclusion

Ubiquitous computing is the inescapable future of public education in the United States. With state funding and private donor stipulations on educational expenditures, school districts are left with little choice but to implement these programs in their schools. Although this pedagogical shift will not be without its obstacles, research suggests that ubiquitous computing initiatives have been successful in many respects and have the potential to improve student academic achievement while preparing them for the technological demands of the workforce when implemented thoughtfully and faithfully.

Mouza (2008) states, “Use of computers can enhance how children learn by supporting four fundamental characteristics of learning: (a) active engagement, (b) participation in groups, (c) frequent interaction and feedback, and (d) connections to real-world contexts” (p. 449). Although student engagement has been contradicted (Donovan, Green, and Hartley, 2010), most studies have supported improvements in the four characteristics listed above with ubiquitous computing programs. “Such opportunities are particularly useful in developing the higher-order skills of critical thinking, analysis, and inquiry that are necessary for success in the 21st century” (Mouza, 2008, p. 449).

Several studies cited above have identified numerous benefits of ubiquitous computing programs (i.e. improved student engagement, motivation, 21st century skills, use of computers for learning, etc.) with little resistance to the contrary. However, student academic achievement on state assessments has not been conclusively proved one way or another. Improved writing skill is the primary academic benefit of ubiquitous computing cited in the literature (Gulek & Demirtas, 2005; Light et al., 2002; Lowther et al., 2001; Peckman, 2008; Penuel, 2006). While some researchers have found improvements in standardized test scores in math, reading, and/or science (Dunleavy & Heinecke, 2008; Gulek & Demirtas, 2005), others have found no difference in test scores (Grimes & Warschauer, 2008). Topper and Lancaster point out that “short-term assessments of student achievement, measured via standardized tests, is not likely to show improvements, identifying and measuring students' acquisition of 21st-century literacy skills are likely to be realized, even in the short term" (p. 357). "It is likely that to expect achievement gains, one-to-one initiatives would need to be part of a larger, more comprehensive effort to improve instruction" (Penuel, 2006, p. 341).

To sum, ubiquitous computing has been praised as containing numerous learning benefits, including improved 21st century skills (Mouza, 2008; Rockman, 2003); active engagement; participation in groups; frequent interaction and feedback; and connection to real-world contexts (Mouza, 2008; Roschelle et al., 2000); improved writing skills (Mouza, 2008; Penuel, 2006; Russell, Bebell, & Higgins, 2004); a better attitude towards school (Mouza, 2008); and motivation and persistence in completing work (Mouza, 2008). Additionally, studies have found that ubiquitous computing initiatives improve student writing skills (Gulek & Demirtas, 2005; Grimes & Warschauer, 2008; Light et al., 2002; Lowther, Ross, & Morrison, 2003; Mouza, 2008; Peckham, 2008; Penuel, 2006; Russell, Bebell, & Higgins, 2004); improve motivation and engagement in learning (Grimes & Warschauer, 2008; Li & Pow,2011; Lowther, Ross, & Morrison, 2003; Mouza, 2008); improve student math skills (Mouza, 2008); improve student problem-solving skills (Penuel, 2006); and improve student science scores (Dunleavy & Heinecke, 2007).

It is important to note that much of this research has been contested or contradicted by studies that have found the opposite or no relationship between ubiquitous computing and student engagement or achievement. Furthermore, many of the studies did not implement rigorous empirical research methods and relied on observations, student surveys and teacher interviews. It is still necessary to research the effects of ubiquitous computing on student achievement in standardized state tests and to do so over a period of time. Additionally, research still needs to investigate differences in gender as well as content area in relation to ubiquitous computing.

> The typical experience of schools in 1:1 computing initiatives is quite different. One researcher experienced in researching 1:1 computing recently wrote: 'We consistently find substantive impacts on teaching and learning, on teachers and students, yet we continue to have difficulty tying full-time access to computers to the outcomes of standardized tests currently in use' (Rockman, 2003).

There could be numerous reasons for the fact that there is no consensus on the effects of one-to-one initiatives on student scores on standardized assessments. Zucker (2004) states:

> One likely possibility is that because choices about how to use technology are often left to individual students and teachers (rather than being focused on particular learning goals across an entire state, district, or school, as was the case at W. L. Parks), impacts on student achievement are weak and scattered. Studies of focused interventions involving 1:1 computing will be useful to establish what is possible. (p. 378)

Students using educational technologies have been shown to have more positive attitudes towards learning and focus more closely on learning goals. Student learning outcomes remains debatable due to conflicting findings. Over time, measured effect sizes for educational technology has typically been between 0.3 and .4, slightly lower than average; however, effect sizes ranged between -.03 and 1.05 depending on the type of technology and their implementation. Studies by Tamim et al. (2011) and others point to a need for research focusing on the context in which technology contributes to learning. “These studies point to the dangers of focusing on technology only while ignoring issues of teachers’ technological and pedagogic expertise when evaluating the effects of technology use” (Ng, 2015, p. 15).

There are two issues that impact the conflicting findings in the literature regarding technology. “The first is that technology is often examined at a very general level” (Lei, 2010, p. 457). The second issue is, “Most studies focus on the impact of the quantity of technology use, in other words, how much or how frequently technology is used, but ignore the quality of technology use, that is, how technology is used” (Lei, 2010, p. 458). This study sought to add to the growing body of literature about the effects of one-to-one initiatives on student academic achievement on standardized assessments in mathematics and reading.

CHAPTER III: METHODOLOGY

Introduction

The primary objective of this study was to determine the difference in student academic achievement on standardized state assessments in reading and mathematics between students receiving one-to-one digital instruction and those receiving other traditional modes of instruction as described in Chapter I. A secondary purpose of this study was to determine what effects one-to-one initiatives have on students by grade level, gender, and SES. This study used a pretest-posttest control group design to test the research questions. The methodology used is presented in four sections of this chapter: (a) selection of participants, (b) instrumentation, (c) data collection, and (d) data analysis.

Selection of Participants

The school district used for this study served over 186,000 students in 184 schools in Florida in the 2013-2014 school year (OCPS, 2014b). Of the total student population, 35.6% were Hispanic, 29.7% were White, 27.3% were Black, 4.5% were Asian, and 2.3% were multi-racial (FLDOE, 2015). FLDOE (2015) student enrollment data also shows 61.1% of students qualify for free or reduced lunch, 11.1% of students qualify as students with disabilities, and 13.1% qualify as English language learners (ELLs). School district demographic data gathered from FLDOE (2015) Education Information Portal are shown in Table 8.

Table 8: School District Student Population Demographic Data

Race/Ethnicity	Percent of Student Population	Qualify for Free or Reduced Lunch	ELL	Disability
Hispanic	35.6%	43.3%	71.6%	38.5%
White	29.7%	15.3%	5.2%	28.2%
Black	27.3%	35.7%	17.0%	28.4%
Asian	4.5%	3.2%	5.7%	2.4%
Multi-racial	2.3%	2.0%	0.3%	2.1%
Other	0.6%	0.5%	0.6%	0.4%

The Digital Curriculum Pilot Program (DCPP) was developed in 2012 "in response to changing student, workforce, community, and legislative requirements" (OCPS, 2014b, p. 11). The school district selected seven schools representative of the overall school district population for the DCPP which began during the 2013-2014 school year. "The schools varied in level, size, academic performance, and free and reduced lunch rate" (OCPS, 2014b, p. 11). The sample for this study was comprised of 19 schools: the seven DCPP schools—one high school, three middle schools, and three elementary schools—and 12 randomly selected schools stratified by school level; six elementary schools, five middle schools, and one high school. Data collected from the school district yielded a sample size of 16,188 students who received scores on the FCAT 2.0 Reading and 12,472 students who received scores on the FCAT 2.0 Mathematics for the 2013-2014 school year.

Student demographics at the DCPP schools were comparable to the district demographics by race and ethnicity. DCPP schools had an average Hispanic student population of 39.1%, comparable to the school district Hispanic student population of 35.6%. White students made up 25.1% of the DCPP school population while making up 29.7% of the school district population, and Black students made up 28.3% of the DCPP school population while making up 27.3% of the school district population. Table 9 shows enrollment demographics by race and ethnicity for the DCPP schools compared to the entire school district. A DCPP school average was calculated by combining raw enrollment numbers for each category in each school, then dividing by the total combined student population.

Table 9: DCPP Students by Race/Ethnicity

Race/Ethnicity	ES1	ES2	ES3	MS1	MS2	MS3	HS	District	DCPP School Average
Hispanic	44.2%	13.2%	62.0%	71.2%	47.5%	32.7%	21.7%	35.6%	42.4%
White	7.6%	2.7%	11.7%	15.9%	33.4%	47.4%	31.1%	29.7%	27.4%
Black	42.5%	81.8%	18.9%	7.9%	7.0%	10.2%	39.6%	27.3%	22.5%
Other	0.9%	2.3%	1.0%	0.4%	0.5%	1.0%	1.1%	7.4%	7.7%

Student demographics for disability status, ELL status, and free or reduced lunch status at the DCPP schools were comparable to the district demographics. Of the students at DCPP schools in 2013-2014, 70.6% qualified for free or reduced lunch, 13.3% were listed as ELLs, and 9.7% were listed as having a disability. The school district ranked lower in percent of students who qualified for free or reduced lunch (61.1%), about the same in students who were listed as ELLs (13.1%), and higher in students who were listed as having a disability (11.1%). Table 10 shows enrollment demographics by disability, ELL, and free or reduced lunch status for the DCPP schools compared to the entire school district. A DCPP school average was calculated by combining raw enrollment numbers for each category in each school, then dividing by the total combined student population.

Table 10: DCPP Students by Disability, ELL, and Free or Reduced Lunch Status

Race/Ethnicity	ES1	ES2	ES3	MS1	MS2	MS3	HS	District	DCPP School Average
Qualify for Free or Reduced Lunch	100%	100%	80.2%	83.1%	47.8%	55.7%	60.3%	61.1%	70.6%
ELL	31.3%	21.6%	28.1%	13.9%	9.2%	5.5%	4.6%	13.1%	13.3%
Disability	11.6%	6.1%	6.6%	15.9%	4.8%	11.8%	9.4%	11.1%	9.7%

The target population of this study consisted of the 186,000 students in the school district. A sample size of 383 was required as suggested by Krejcie and Morgan (1970). Nineteen schools were selected overall for the study (N=19). In addition to the seven DCPP schools, a stratified random sample of schools (N=12) was selected; six elementary schools, five middle schools, and one high school.

Instrumentation

The first operational tests for the FCAT were administered in 1998 after field testing the previous year (FLDOE, 2005). The FCAT was used to measure student academic achievement in grades 3-10 and were based on benchmarks found in the Sunshine State Standards (SSS), which were adopted by the Florida State Board of Education in 1996 (FLDOE, 2005). In 2011, the FCAT was replaced by the FCAT 2.0 with the purpose of measuring student achievement on the newly adopted set of standards, the Next Generation Sunshine State Standards (NGSSS), in reading, writing, science, and mathematics (FLDOE, n.d.).

This study uses two assessments to evaluate student achievement, the FCAT 2.0 Reading and the FCAT 2.0 Mathematics. The FCAT 2.0 Reading is a 140 minute assessment administered in two 70 minute sessions for all students in grades three through 10. It consists of 50-55 items forming four content categories: vocabulary; reading application; literary analysis: fiction and nonfiction; and informational text and research process (FLDOE, n.d.).

The FCAT 2.0 Mathematics assessment for grades three through eight is administered in two 70 minute sessions. The assessments for grades three through seven consist of 50-55 items, while the eighth grade FCAT 2.0 Mathematics consists of 60-65 items forming numerous content categories that build upon each other from one year to the next (FLDOE, n.d.). Unlike the FCAT 2.0 Reading, the mathematics section does not have assessments for ninth and 10^{th} grade students. Instead, the (FLDOE, n.d.), uses geometry and algebra 1 end of course exams (EOCs) to evaluate student achievement. Like the eighth grade FCAT 2.0 Mathematics assessment, the geometry and algebra 1 EOCs consist of 60-65 items. Table 11 shows the FCAT 2.0 Mathematics, Geometry EOC, and Algebra 1 EOC Content Categories.

Table 11: FCAT 2.0 Mathematics, Geometry EOC, and Algebra 1 EOC Content Categories

Grade/Assessment	Category	Percentage
3	Number: Operations, Problems, and Statistics	50
	Number: Fractions	20
	Geometry and Measurement	30
4	Number: Operations and Problems	45
	Number: Base Ten and Fractions	25
	Geometry and Measurement	30
5	Number: Base Ten and Fractions	50
	Expressions, Equations, and Statistics	20
	Geometry and Measurement	30
6	Fractions, Ratios, Proportional Relationships, and Statistics	40
	Expressions and Equations	40
	Geometry and Measurement	20
7	Number: Base Ten	25
	Ratios and Proportional Relationships	25
	Geometry and Measurement	30
	Statistics and Probability	20
8	Number: Operations, Problems, and Statistics	25
	Expressions, Equations, and Functions	40
	Geometry and Measurement	35
Geometry EOC	Two-Dimensional Geometry	65
	Three-Dimensional Geometry	20
	Trigonometry and Discrete Mathematics	15
Algebra 1 EOC	Functions, Linear Equations, and Inequalities	55
	Polynomials	20
	Rationals, Radicals, Quadratics, and Discrete Mathematics	25

Note: Adapted from *Test Design Summary: 2013-2014 Operational Assessments*, by the FLDOE, n.d., p. 2-3.

Test items are categorized by difficulty and cognitive complexity (FLDOE, 2012b). Item difficulty refers to the percentage of students who answer the question item correctly. Items are categorized as easy (70% or more correct), average (40%-70% correct), and challenging (less than 40% correct) (FLDOE, 2012b). “Cognitive complexity refers to the cognitive demand associated with an item” (FLDOE, 2012b, p. 1). According to the FLDOE (FLDOE, 2012b), cognitive complexity for the FCAT 2.0 is measured using a “cognitive classification system based on Dr. Norman L. Webb's Depth of Knowledge (DOK) levels" (p. 1) which focuses on the expectations of the items rather than student ability. Complexity levels are categorized as low complexity, moderate complexity, and high complexity. "Low-complexity items rely heavily on recall and recognition. Moderate-complexity items require more flexible thinking and may require informal reasoning or problem solving. High-complexity items are written to elicit analysis and abstract reasoning" (FLDOE, n.d.).

In 2013, FCAT 2.0 assessments were transitioning from paper-pencil format to computer-based testing (CBT). Students in grades seven and 10 were administered the computer-based version of the FCAT 2.0 Reading, along with some students in grades six and nine. Additionally, some students in grade five were administered computer-based version of the FCAT 2.0 Mathematics (FLDOE, 2013). In 2014, FCAT 2.0 Reading for grades six through 10, and FCAT 2.0 Mathematics for grades five and six were all computer-based tests (FLDOE, 2014b). "Accommodated test forms (i.e., large print, braille, and one-item-per-page), including regular print paper-based versions of computer-based tests, are provided for students with disabilities who require allowable accommodations, as specified in their Individual Educational Plans (IEPs) or Section 504 plans" (FLDOE, 2014b).

Two types of question formats appear in the FCAT 2.0 Reading and Mathematics. Multiple choice (MC) questions for which students select the best response from four answer choices appear in both the FCAT 2.0 Reading and Mathematics assessments. Gridded-response and fill-in response questions for which students enter responses into a grid or type in answers appear on the FCAT 2.0 Mathematics assessments for grades four through eight (FLDOE, 2014b).

FCAT 2.0 scores are reported in various forms. Reading and mathematics developmental scale scores (DSS) link assessment results for individual students from year to year in order to determine student academic progress (FLDOE, 2014b). The FCAT 2.0 Reading developmental score scale ranges from 140 to 302 and the FCAT 2.0 Mathematics scale ranges from 140 to 298 (FLDOE, 2014b). The DSS are tied in to a second way in which scores are reported—through achievement levels. "Achievement Levels describe the level of success a student has achieved with the content assessed. Achievement Levels range from 1 (lowest) to 5 (highest)" (FLDOE, 2014b, p. 6). Students must earn a level three or higher on the FCAT Reading and Mathematics to pass each respective test. An achievement level of three represents a satisfactory understanding of the grade level benchmarks (FLDOE, 2014b). Table 12 shows achievement levels for the FCAT 2.0 Reading DSS and Table 13 shows achievement levels for the FCAT 2.0 Mathematics DSS.

Table 12: Achievement Levels for the
FCAT 2.0 Reading Developmental Scale Score

Grade	Level 1	Level 2	Level 3	Level 4	Level 5
3	140-181	182-197	198-209	210-226	227-260
4	154-191	192-207	208-220	221-237	238-269
5	161-199	200-215	216-229	230-245	246-277
6	167-206	207-221	222-236	237-251	252-283
7	171-212	213-227	228-242	243-257	258-289
8	175-217	218-234	235-248	249-263	264-296
9	178-221	222-239	240-252	253-267	268-302
10	188-227	228-244	245-255	256-270	271-302

Note: Reprinted from *Understanding FCAT 2.0 Reports*, by the FLDOE, 2014, p. 6.

Table 13 Achievement Levels for the
FCAT 2.0 Mathematics Developmental Scale Score

Grade	Level 1	Level 2	Level 3	Level 4	Level 5
3	140-182	183-197	198-213	214-228	229-260
4	155-196	197-209	210-223	224-239	240-271
5	163-204	205-219	220-233	234-246	247-279
6	170-212	213-226	227-239	240-252	253-284
7	179-219	220-233	234-247	248-260	261-292
8	187-228	229-240	241-255	256-267	268-298

Note: Reprinted from *Understanding FCAT 2.0 Reports*, by the FLDOE, 2014, p. 6.

In addition to DSS and achievement levels, FCAT 2.0 results are reported using content area scores. "Content area scores are the actual number of questions answered correctly within each reporting category" (FLDOE, 2014b, p. 7). Content area scores are especially beneficial for comparing student achievement on any of the content categories to other schools, districts, or to the state average.

The FCAT 2.0 Reading and Mathematics were evaluated for validity and reliability separately. According to (FLDOE, 2012c), in developing test items for the FCAT 2.0 Reading, the following guidelines applied:

1. Each item should be written to measure primarily one benchmark; however, other benchmarks may also be reflected in the item content.
2. Items should be grade-level appropriate in terms of item difficulty, cognitive demands, and reading level.
3. At a given grade, the items should exhibit a varied range of difficulty.
4. The reading level of items should be on or below the grade level of the test, with the exception of items that require the student to use context clues to determine the meaning of unfamiliar words and phrases, which may be two grade levels above the tested grade.

5. Items should not disadvantage or exhibit disrespect to anyone in regard to age, gender, race, ethnicity, language, religion, socioeconomic status, disability, occupation, or geographic region.
6. Items should require students to apply the reading skills described in the NGSSS benchmarks from lower grade levels. Skills previously taught in lower grades will continue to be tested at higher grade levels.
7. Some items may include an excerpt from the associated passage in addition to the item stem.
8. Items should provide clear, concise, and complete instructions to students.
9. Each item should be written clearly and unambiguously to elicit the desired response. (p. 2).

The length of each reading passage for the FCAT 2.0 Reading increased from an average of 500 words per passage in third grade to 1,000 words per passage in 10th grade (FLDOE, 2012b). Additionally, every text that appeared on the FCAT 2.0 Reading was first required to pass through a review process including scrutiny from educators, citizens, and the FLDOE. Each text was reviewed for appropriateness of grade-level content, potential bias, and community sensitivity (FLDOE, 2012b). "This review focuses on validity and determines if an item is a valid measure of the designated NGSSS benchmark, as defined by the grade-level specifications for test items. Separate reviews for bias and sensitivity issues are also conducted" (FLDOE, 2012b, p. 9). After initial review and approval, test items are field tested before counting toward student scores (FLDOE, 2012b).

According to (FLDOE, 2012c), in developing test items for the FCAT 2.0 Mathematics, the following guidelines applied:

1. Each item should be written to measure primarily one benchmark; however, other benchmarks may also be reflected in the item content.
2. When benchmarks are combined for assessment, the individual specification indicates which benchmarks are combined.
3. Items should be appropriate for students in terms of grade-level difficulty, cognitive development, and reading level.
4. At a given grade, the test items will exhibit a varied range of difficulty.
5. For mathematics items, the reading level should be approximately one grade level below the grade level of the test, except for specifically assessed mathematical terms or concepts.
6. Items should not disadvantage or exhibit disrespect to anyone in regard to age, gender, race, ethnicity, language, religion, socioeconomic status, disability, or geographic region.
7. At Grades 3–6, all items should be written so they can be answered without using a calculator. At Grades 7 and 8, students are allowed to use a four-function calculator, although items should still be written to be answered without a calculator within the timing guidelines for each item type. For the Algebra 1 EOC Assessment, a four-function calculator will also be allowed. For the Geometry EOC Assessment, a scientific calculator will be used.

8. Items may require the student to apply mathematical knowledge described in NGSSS benchmarks from lower grades; however, the benchmarks from lower grades will not be assessed in isolation.
9. Some items should provide information for students to analyze and use in order to respond to the items.
10. Items should provide clear and complete instructions to students.
11. Each item should be written clearly and unambiguously to elicit the desired response.
12. A reference sheet containing appropriate formulas and conversions is provided to students in Grades 5, 6–8, 10 (1996 Standards), Algebra 1 EOC, and Geometry EOC for use during testing. Copies of the reference sheets are included in Appendix G of this document.
13. Items on the FCAT 2.0 and EOC assessments should be written so that students are expected to select or provide the most accurate answer possible. Students should not round decimal equivalents and/or approximations until the final step of the item or task. Whenever possible, the item stem should specify the decimal place, equivalent fraction, and/or pi approximation needed for the answer. In most cases, front-end estimation and truncation are not accurate processes for estimation.
14. The FCAT 2.0 Mathematics Grades 3 and 4 tests will require the use of a six-inch ruler with both metric and standard units. The metric edge will be in millimeter and centimeter increments. The standard edge will be in and one-inch increments. (p. 2-3)

Like the FCAT 2.0 Reading, the Mathematics section of the FCAT 2.0 requires a review process before question items are counted towards student scores. Each question item is reviewed by

Florida educators, citizens, and the FLDOE for content characteristics, item specifications, potential bias, community sensitivity (FLDOE, 2012d). "The content review focuses on validity, determining whether each item is a valid measure of the designated NGSSS benchmark" (FLDOE, 2012d, p. 17). Additionally, question items are field tested once they pass through the initial review process for further evidence of validity. Items that test poorly are either removed or revised (FLDOE, 2012d).

Data Collection

The first step in the collection of archival student academic achievement data from the school district was to complete the Institutional Review Board (IRB) approval process at the University of Central Florida (UCF). After IRB approval was granted, an application to conduct research at the school district was submitted. A summary of the study, recent completion of Collaborative Institutional Training Initiative (CITI) training involving human research, and a signed dissertation proposal defense form were submitted along with the application to conduct research.

Once the application to conduct research was reviewed and accepted, the school district provided the researcher with student academic achievement data for all students who attended DCPP schools and a proportional stratified random sample of schools to match DCPP schools by grade level. The school district provided student DSS for the sample population for 2012-2013 FCAT 2.0 Reading, 2012-2013 FCAT 2.0 Mathematics, 2013-2014 FCAT 2.0 Reading, and 2013-2014 FCAT 2.0 Mathematics.

Data Analysis

For questions one and two, student DSS in the 2013-2014 FCAT 2.0 Reading and Mathematics for students receiving one-to-one digital instruction were compared to the 2013-2014 FCAT 2.0 Reading and Mathematics DSS of students receiving other traditional forms of instruction using an independent samples t-test. Whether or not a student attended the DCPP school from 2012-2014 was the independent variable. Student scores on the 2013-2014 version of the FCAT 2.0 Reading and Mathematics were the dependent variables. Following is the statistical analysis that was conducted for each assessment—FCAT 2.0 Reading and FCAT 2.0 Mathematics for each school level; elementary school, middle school, and high school.

$$t = \frac{\overline{x} - \mu_0}{s/\sqrt{n}}$$

Data were analyzed using the IBM SPSS software package to run statistical tests. In addition to the t-test described above, descriptive statistics and tables were also used to display mean scores on the various assessments for the two years of study as well as for student subpopulations.

For questions three and four, a Factorial ANCOVA was conducted to determine whether a combination of student gender, SES, and grade level predicted the change in student DSS on the FCAT 2.0 Reading and Mathematics. Additional a repeated measures ANOVA was conducted to determine the effects of the intervention on student academic achievement. Following is the general model for an ANOVA test where the F ratio is equal to the variance between groups divided by the variance within groups.

$$F = \frac{MS_{between}}{MS_{within}}$$

Summary

This chapter restated the objectives of the study and the questions it sought to answer. It included a detailed description of the study participants as well as the target population. The participants were chosen through a proportional stratified random sample of students in the school district and compared to the treatment group (pre-selected by the school district). The selection of the 28,660 participants was discussed. The validity of the instrument used to assess student academic achievement—FCAT 2.0 Reading and Mathematics—was discussed as well as the procedure for question item development and adoption. The data collection procedures were also discussed in this chapter. Finally, the methods used for data analysis were discussed including descriptions of formulas for each statistical test. Results of the data analysis are presented in the next chapter.

CHAPTER IV: RESULTS

Introduction

This study intended to investigate the differences in FCAT 2.0 Reading and Mathematics scores between students receiving one-to-one digital instruction and students receiving other traditional modes of instruction. Additionally, this study sought to determine the effects of one-to-one computer initiatives on student academic achievement overall and their effects on student academic achievement based on student gender, SES, and grade level. The purpose of this study was achieved by analyzing archival student data for two consecutive school years—2012-2013 (the baseline year) and 2013-2014 (the first year of DCPP implementation). Student FCAT 2.0 Reading and Mathematics DSS along with student demographic data were used to compare DCPP schools to non-DCPP schools for 2013-2014, and to compare student achievement at DCPP schools before program implementation (2012-2013) and after (2013-2014). This chapter presents the results of the data analysis for the four stated research questions.

First, descriptive statistics were reported for student academic achievement by school level and subject followed by the results of the independent-samples t-test, repeated measures ANOVA, and factorial ANCOVA tests. The findings are presented by the four research questions. An independent-samples t-test was used to answer questions one and two: "What is the difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction?" and "What is the difference in FCAT 2.0 Mathematics scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction?"

A repeated measures ANOVA was used to answer research questions three and four: "What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?" and "What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?" Additionally, a factorial ANCOVA was used to compare mean differences between elementary, middle, and high school FCAT 2.0 Reading and Mathematics DSS.

Descriptive Statistics

Student Achievement Variables

FCAT 2.0 Reading and Mathematics DSS for the school years 2012-2013 and 2013-2014 were used to gather student achievement information. These data on student achievement were used to compare student outcomes at DCPP schools and non-DCPP schools in 2013-2014, and student outcomes at DCPP schools before and after program implementation. Student achievement is defined as student DSS on the FCAT 2.0 Reading and Mathematics. Table 14 and 15 report the mean percentage and standard deviation of student DSS in reading and mathematics for 2013-2014 by school level and DCPP participation.

Table 14: Student FCAT 2.0 Reading DSS for 2013-2014

	DCPP					
	Yes			No		
School Level	*n*	*M*	*SD*	*n*	*M*	*SD*
Elementary School	1117	206.22	21.896	2049	208.32	24.267
Middle School	3346	232.24	22.516	5910	230.51	21.660
High School	1174	237.41	20.178	2592	238.72	20.049

Table 15: Student FCAT 2.0 Mathematics DSS for 2013-2014

	DCPP					
	Yes			No		
School Level	*n*	*M*	*SD*	*n*	*M*	*SD*
Elementary School	1119	208.86	23.268	2052	210.09	23.996
Middle School	3348	236.31	22.412	5953	232.78	21.223

Demographic Variables

Demographic variables provide relevant information about the types of students who attended the schools in this study. These data include student gender, ethnicity, and SES as determined by free or reduced lunch status (FRL). Table 16 shows the percentage of total Black, Hispanic, White, and Other students whose FCAT 2.0 Reading DSS were used in this study. Table 17 shows the percentage of males to females, and table 18 shows the percentage of students receiving free or reduced lunch.

Table 16: Student Ethnicity by DCPP for
FCAT 2.0 Reading

	DCPP					
	Yes		No		Overall	
Ethnicity	Frequency	Percent	Frequency	Percent	Frequency	Percent
Black	1270	22.5	2616	24.8	3889	24.0
Hispanic	2390	42.4	4265	40.4	6657	41.1
White	1544	27.4	3045	28.9	4589	28.3
Other	433	7.7	625	5.9	1058	6.5

Table 17: Student Gender by DCPP for
FCAT 2.0 Reading

	DCPP					
	Yes		No		Overall	
Gender	Frequency	Percent	Frequency	Percent	Frequency	Percent
Female	2806	49.8	5221	49.5	8027	49.6
Male	2831	50.2	5330	50.5	8161	50.4

Table 18: Free or Reduced Lunch Status by DCPP for
FCAT 2.0 Reading

	DCPP					
	Yes		No		Overall	
FRL	Frequency	Percent	Frequency	Percent	Frequency	Percent
No	1733	30.7	3009	28.5	4742	29.3
Yes	3904	69.3	7542	71.5	11446	70.7

Table 19 shows the percentage of total Black, Hispanic, White, and Other students whose FCAT 2.0 Mathematics DSS were used in this study. Table 20 shows the percentage of males to females, and table 21 shows the percentage of students receiving free or reduced lunch.

Table 19: Student Ethnicity by DCPP for
FCAT 2.0 Mathematics

	DCPP					
	Yes		No		Overall	
Ethnicity	Frequency	Percent	Frequency	Percent	Frequency	Percent
Black	798	17.9	2412	30.1	3210	25.7
Hispanic	2122	47.5	2693	33.6	4815	38.6
White	1196	26.8	2405	30.0	3601	28.9
Other	351	7.9	495	6.2	846	6.8

Table 20: Student Gender by DCPP for
FCAT 2.0 Mathematics

	DCPP					
	Yes		No		Overall	
Gender	Frequency	Percent	Frequency	Percent	Frequency	Percent
Female	2234	50.0	3988	49.8	6222	49.9
Male	2233	50.0	4017	50.2	6250	50.1

Table 21: Free or Reduced Lunch Status by DCPP for
FCAT 2.0 Mathematics

	DCPP					
	Yes		No		Overall	
FRL	Frequency	Percent	Frequency	Percent	Frequency	Percent
No	1348	30.2	2331	29.1	3679	29.5
Yes	3119	69.8	5674	70.9	8793	70.5

Testing the Research Questions

Descriptive and inferential statistics were used to answer the four research questions in this study. To analyze research questions one and two, an independent-samples t-test was used to compare the mean FCAT 2.0 Reading and Mathematics DSS between students in DCPP schools and students in comparison schools. Research questions three and four were studied using a factorial ANCOVA and a repeated measures ANOVA. The repeated measures ANOVA was used to determine the effects of the one-to-one initiative on student academic achievement after controlling for prior achievement using the baseline year, and also to compare DSS by student gender, SES, and grade level. The factorial ANCOVA was used to determine mean differences in student DSS by school level—elementary, middle, and high school. The significance level of .05 was used for every statistical analysis used in this study.

Research Question 1

Question 1: What is the difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction? The first research question examined the mean difference in FCAT 2.0 Reading DSS between students in DCPP schools and students in comparison schools. In order to fully examine this question, the results are reviewed in three parts: (1) FCAT 2.0 Reading DSS for elementary school students; (2) FCAT 2.0 Reading DSS for middle school students; and (3) FCAT 2.0 Reading DSS for high school students. As can be seen in Table 22, the DCPP and non-DCPP distributions were sufficiently normal for the purposes of conducting a t-test (i.e., skew $< |2.0|$ and kurtosis $< |9.0|$) (Schmider, Ziegler, Danay, Beyer, & Bühner, 2010). A graphical representation of the data distribution is displayed in Figure 1.

Table 22: Descriptive Statistics for FCAT 2.0 Reading DSS

	n	*M*	*SD*	Skew	Kurtosis
FCAT 2.0 DSS	16188	228.2	24.29	-0.285	0.131

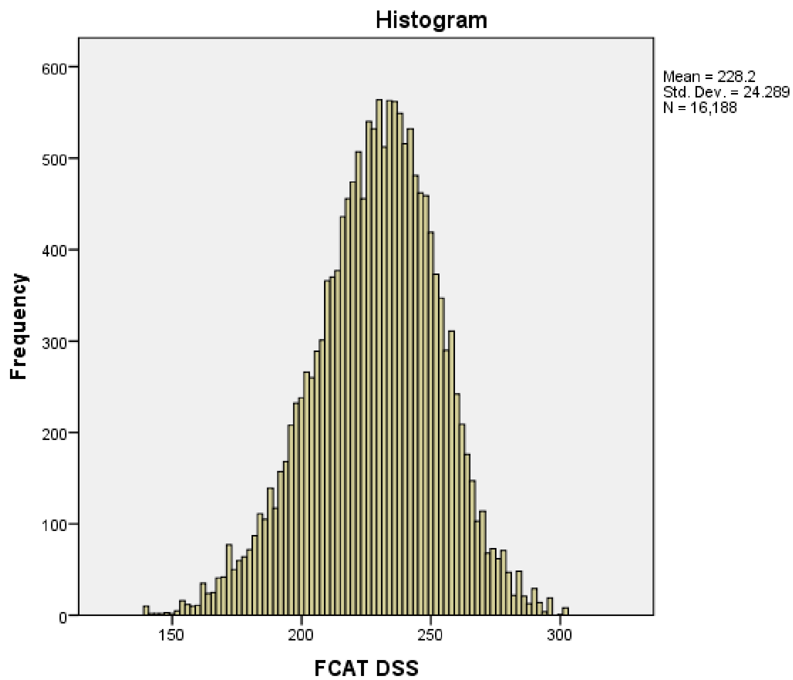

Figure 1: FCAT 2.0 Reading DSS

FCAT 2.0 Reading DSS for Elementary Schools

An independent-samples t-test was used to compare FCAT 2.0 Reading DSS from students who attended DCPP elementary schools and those who attended comparison elementary schools. As can be seen in Table 23, students who attended DCPP elementary schools in 2013-2014 had lower DSS on the FCAT 2.0 Reading (M=206.2, SD=21.9) than students who attended comparison schools (M=208.3, SD=24.3). The assumption of homogeneity of variance was tested via Levene's F test, F(2500.10) = 15.35, p = .000, and was found to be significant, signifying a difference in variance. The independent-samples t-test was associated with a statistically significant effect, t(2500.10) = 2.48, p = .013. Although DCPP effectiveness cannot be gleaned from this analysis, these results suggest that elementary school students who received traditional modes of instruction fared better on the FCAT 2.0 Reading than students who received one-to-one digital instruction.

Table 23: FCAT 2.0 Reading DSS for DCPP and non-DCPP Elementary School Students

	DCPP	*n*	*M*	*SD*	*SEM*	*t*	*df*	*p*
FCAT DSS	No	2049	208.32	24.267	0.536	2.479	2500.1	0.013
	Yes	1117	206.22	21.896	0.655			

FCAT 2.0 Reading DSS for Middle Schools

An independent-samples t-test was used to compare FCAT 2.0 Reading DSS from students who attended DCPP middle schools and those who attended comparison middle schools. As can be seen in Table 24, students who attended DCPP middle schools in 2013-2014 had higher DSS on the FCAT 2.0 Reading (M=232.2, SD=22.5) than students who attended comparison schools (M=230.5, SD=21.7). The assumption of homogeneity of variance was tested and satisfied via Levene's F test, F(9254) = 1.48, p = .223. The independent-samples t-test was associated with a statistically significant effect, t(9254) = -3.63, p = .000. Although DCPP effectiveness cannot be gleaned from this analysis, these results suggest that middle school students who received one-to-one digital instruction fared better on the FCAT 2.0 Reading than students who received traditional modes of instruction.

Table 24: FCAT 2.0 Reading DSS for DCPP and non-DCPP Middle School Students

	DCPP	*n*	*M*	*SD*	*SEM*	*t*	*df*	*p*
FCAT DSS	No	5910.00	230.51	21.66	0.28	-3.63	9254.00	0.000
	Yes	3346.00	232.24	22.52	0.39			

FCAT 2.0 Reading DSS for High Schools

An independent-samples t-test was used to compare FCAT 2.0 Reading DSS from students who attended DCPP high schools and those who attended comparison high schools. As can be seen in Table 25, students who attended DCPP high schools in 2013-2014 had lower DSS on the FCAT 2.0 Reading (M=237.4, SD=20.2) than students who attended comparison schools (M=238.7, SD=20.0). The assumption of homogeneity of variance was tested and satisfied via Levene's F test, F(3764) = .16, p = .688. The independent-samples t-test was not associated with a statistically significant effect, t(3764) = 1.86, p = .064. These results suggest that there was no statistically significant difference in FCAT 2.0 Reading DSS between students who attended DCPP high schools and those who attended comparison high schools.

Table 25: FCAT 2.0 Reading DSS for DCPP and non-DCPP High School Students

	DCPP	*n*	*M*	*SD*	*SEM*	*t*	*df*	*p*
FCAT DSS	No	2592	238.72	20.049	0.394	1.855	3764	0.064
	Yes	1174	237.41	20.178	0.589			

Research Question 2

Question 2: What is the difference in FCAT 2.0 Mathematics scores between students in elementary and middle schools implementing one-to-one initiatives and students receiving traditional modes of instruction? The second research question examined the mean difference in FCAT 2.0 Mathematics DSS between students in DCPP schools and students in comparison schools. In order to fully examine this question, the results are reviewed in two parts: (1) FCAT 2.0 Mathematics DSS for elementary school students; and (2) FCAT 2.0 Mathematics DSS for middle school students. As can be seen in Table 26, the DCPP and non-DCPP distributions were sufficiently normal for the purposes of conducting a t-test (i.e., skew <|2.0| and kurtosis <|9.0|) (Schmider, Ziegler, Danay, Beyer, & Bühner, 2010). A graphical representation of the data distribution is displayed in Figure 2.

Table 26: Descriptive Statistics for FCAT 2.0 Mathematics DSS

	n	*M*	*SD*	Skew	Kurtosis
FCAT 2.0 DSS	12472	227.85	24.66	-0.378	0.033

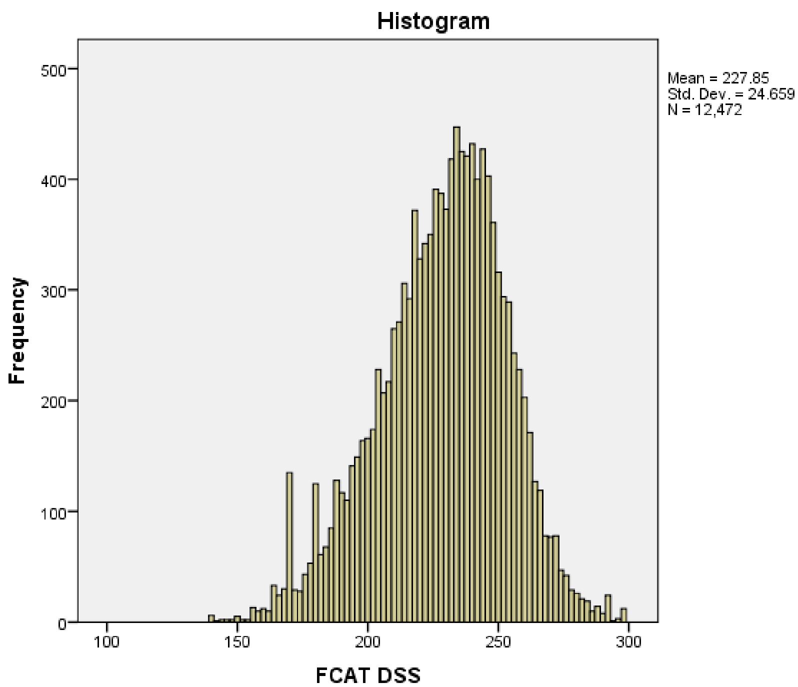

Figure 2” FCAT 2.0 Mathematics DSS

FCAT 2.0 Mathematics DSS for Elementary Schools

An independent-samples t-test was used to compare FCAT 2.0 Mathematics DSS from students who attended DCPP elementary schools and those who attended comparison elementary schools. As can be seen in Table 27, students who attended DCPP elementary schools in 2013-

2014 had lower DSS on the FCAT 2.0 Mathematics (M=208.9, SD=23.3) than students who attended comparison schools (M=210.09, SD=24.0). The assumption of homogeneity of variance was tested and satisfied via Levene's F test, F(3169) = 0.51, p = .474. The independent-samples t-test was not associated with a statistically significant effect, t(3169) = 1.39, p = .164. These results suggest that there was no statistically significant difference in FCAT 2.0 Mathematics DSS between students who attended DCPP elementary schools and those who attended comparison elementary schools.

Table 27: FCAT 2.0 Mathematics DSS for DCPP and non-DCPP Elementary School Students

	DCPP	*n*	*M*	*SD*	*ESM*	*t*	*df*	*p*
FCAT DSS	No	2052	210.09	23.996	0.53	1.391	3169	0.164
	Yes	1119	208.86	23.268	0.696			

FCAT 2.0 Mathematics DSS for Middle Schools

An independent-samples t-test was used to compare FCAT 2.0 Mathematics DSS from students who attended DCPP middle schools and those who attended comparison middle schools. As can be seen in Table 28, students who attended DCPP middle schools in 2013-2014 had higher DSS on the FCAT 2.0 Mathematics (M=236.3, SD=22.4) than students who attended comparison middle schools (M=232.8, SD=21.2). The assumption of homogeneity of variance was tested via Levene's F test, F(6626.38) = 7.78, p = .005, and was found to be significant, signifying a difference in variance. The independent-samples t-test was associated with a statistically significant effect, t(6626.38) = -7.43, p = .000. Although DCPP effectiveness cannot be gleaned from this analysis, these results suggest that middle school students who received one-to-one digital instruction fared better on the FCAT 2.0 Mathematics than students who received traditional modes of instruction.

Table 28: FCAT 2.0 Mathematics DSS for DCPP and non-DCPP Middle School Students

	DCPP	*n*	*M*	*SD*	*SEM*	*t*	*df*	*p*
FCAT DSS	No	5953	232.78	21.223	0.275	-7.428	6626.38	0.000
	Yes	3348	236.31	22.412	0.387			

Research Question 3

Question 3: What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender? The third research question examined the influence of student grade level, SES, and gender on student FCAT 2.0 Reading DSS for students attending DCPP schools. A repeated measures ANOVA was conducted to compare the main effects of student grade level, SES, and gender and the interaction effect between grade level, SES, and gender on student FCAT 2.0 Reading DSS. Student grade level included eight levels, SES included two levels, and gender included two levels.

As can be seen in Table 29, the assumption of homogeneity of variance was tested and satisfied via Levene's F test, F(5578) = 1.09, p = .338. The repeated measures ANOVA was used to compare the mean change in FCAT 2.0 Reading DSS from 2012-2013 to 2013-2014. The same students attending DCPP schools were measured before and after program implementation. Table 30 shows the assumption of sphericity for the main effect was satisfied, F(1, 5578) = 3.137, p = .077.

As can be seen in Table 31, there was no statistically significant difference between mean FCAT 2.0 Reading DSS scores for 2012-2013 and 2013-2014, $F(1) = 3.137$, $p = .077$. Table 32 shows mean FCAT 2.0 Reading DSS for 2012-2013 (M = 226.99, SE = .4) and 2013-2014(M = 225.87, SE = .5).

As can be seen in Table 33, student grade level and SES were statistically significant at the .05 significance level; no other effects were statistically significant. The main effect for grade level yielded an F ratio of $F(7, 5578) = 95.6$, $p < .001$, indicating a significant difference between third grade (M = 209.6, SE = 1.2), fourth grade (M = 214.3, SE = 1.4), fifth grade (M = 221.8, SE = 1.2), sixth grade (M = 229.1, SE = 0.6), seventh grade (M = 232.8, SE = 0.5), eighth grade (M = 235.8, SE = 0.5), ninth grade (M = 234.8, SE = 0.7), and tenth grade students (M = 233.3, SE = 0.7). Although no statistically significant difference was found between the baseline year and the first year of DCPP implementation, there was a significant interaction effect for grade level and SES, but no interaction effects between subjects (see Table 33). Table 34 shows mean scores with 95% confidence interval for FCAT 2.0 Reading DSS by grade level.

Table 29: Levene's Test of Equality of Error Variances for FCAT 2.0 Reading

	F	*df1*	*df2*	*p*
FCAT2012	2.231	31	5578	.000
FCAT2013	1.088	31	5578	.338

Table 30: Tests of Within-Subjects Effects for FCAT 2.0 Reading

	Source	*SS*	*df*	*MS*	*F*	*p*	Partial Eta Squared
FCAT	Sphericity Assumed	1516.625	1	1516.625	3.137	0.077	0.001
	Greenhouse-Geisser	1516.625	1	1516.625	3.137	0.077	0.001
	Huynh-Feldt	1516.625	1	1516.625	3.137	0.077	0.001
	Lower-bound	1516.625	1	1516.625	3.137	0.077	0.001

Table 31: Multivariate Tests for FCAT 2.0 Reading

Effect		*Value*	*F*	*Hypothesis df*	*Error df*	*p*	Partial Eta Squared
FCAT	Pillai's Trace	.001	3.137	1.000	5578.000	.077	.001
	Wilks' Lambda	.999	3.137	1.000	5578.000	.077	.001
	Hotelling's Trace	.001	3.137	1.000	5578.000	.077	.001
	Roy's Largest Root	.001	3.137	1.000	5578.000	.077	.001

Table 32: Mean Differences for FCAT 2.0 Reading
2012-2013 and 2013-2014

			95% Confidence Interval	
FCAT	Mean	Std. Error	Lower Bound	Upper Bound
1	226.991	.400	226.207	227.776
2	225.867	.502	224.883	226.851

Table 33: Tests of Between-Subjects Effects
for FCAT 2.0 Reading

Source	*SS*	*df*	*MS*	*F*	*p*	Partial Eta Squared
Intercept	245916325.6	1	245916325.6	487495.912	0.000	0.989
GRADE_LVL	337592.069	7	48227.438	95.604	0.000	0.107
SES	23103.225	1	23103.225	45.799	0.000	0.008
GENDER	220.18	1	220.18	0.436	0.509	0
GRADE_LVL * SES	6583.059	7	940.437	1.864	0.071	0.002
GRADE_LVL * GENDER	6683.478	7	954.783	1.893	0.066	0.002
SES * GENDER	1313.558	1	1313.558	2.604	0.107	0
GRADE_LVL * SES * GENDER	1576.809	7	225.258	0.447	0.873	0.001
Error	2813810.805	5578	504.448			

Table 34: FCAT 2.0 Reading DSS by grade level

			95% Confidence Interval	
Grade Level	*M*	*SE*	Lower Bound	Upper Bound
3	209.624	1.207	207.259	211.99
4	214.268	1.404	211.516	217.021
5	221.784	1.23	219.374	224.195
6	229.064	0.564	227.957	230.17
7	232.813	0.477	231.878	233.748
8	235.794	0.495	234.824	236.764
9	234.791	0.732	233.357	236.226
10	233.293	0.683	231.955	234.631

The main effect for SES yielded an F ratio of F(1, 5578) = 45.8, p < .001, indicating a statistically significant difference between students receiving free or reduced lunch and students not receiving free or reduced lunch (see Table 33). As can be seen in Table 35, students with lower SES classifications scored lower (M = 224.2, SE = 0.3) on the FCAT 2.0 Reading than students with higher SES classifications (M = 228.6, SE = 0.6). The main effect for gender yielded an F ratio of F(1, 5578) = 0.436, p > .05, indicating that the effect for gender was not significant; male students (M = 226.6, SE = 0.4) scored nearly the same as female students (M = 226.2, SE = 0.5). The interaction effects of grade level and SES; grade level and gender; SES and gender; and grade level, SES, and gender were all not statistically significant (See Table 33).

Table 35: FCAT 2.0 Reading DSS by SES

			95% Confidence Interval	
SES	*M*	*SE*	Lower Bound	Upper Bound
No FRL	228.624	0.588	227.47	229.777
FRL	224.234	0.273	223.699	224.769

In addition to the repeated measures ANOVA used to analyze the effects of one-to-one initiatives on student DSS on the FCAT 2.0 Reading by gender, grade level, and SES, a factorial

ANCOVA was conducted in order to find out more about the effects one-to-one initiatives had on students at the different school levels—elementary, middle, and high school.

As can be seen in Table 36, the assumption of homogeneity of variance was tested and satisfied via Levene's F test, $F(5578) = 1.09$, $p = .338$. The factorial ANCOVA was not associated with a statistically significant effect, $F(2, 5604) = 1.176$, $p = .309$. The mean difference in growth in FCAT 2.0 Reading DSS was not statistically significant between elementary, middle, and high schools. Not only is the main effect not statistically significantly different, but the interaction effect between school level and DSS was also not statistically significant, $F(3, 5604) = 1.701$, $p = 0.164$. Table 37 shows tests of between-subject effects for FCAT 2.0 Reading.

Table 36: Levene's Test of Equality of Error Variances for FCAT 2.0 Reading ANCOVA

	F	*df1*	*df2*	*p*
FCAT2013	0.683	2	5607	0.505

Table 37: Tests of Between-Subjects Effects for FCAT 2.0 Reading ANCOVA

Source	*SS*	*df*	*MS*	*F*	*p*	Partial Eta Squared
Corrected Model	84454.145[a]	5	16890.83	27.835	0.000	.024
Intercept	1560433	1	1560433	2571.515	0.000	0.315
School Level	1426.806	2	713.403	1.176	0.309	.000
School level * FCAT2012	3097.01	3	1032.337	1.701	0.164	0.001
Error	3400589	5604	606.815			
Total	2.95E+08	5610				
Corrected Total	3485043	5609				

a. R Squared = .024 (Adjusted R Squared = .023)

Research Question 4

Question 4: What is the difference in student academic achievement growth in FCAT 2.0 Mathematics scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender? The fourth research question examined the influence of student grade level, SES, and gender on student FCAT 2.0 Mathematics DSS for students attending DCPP schools. Only scores for elementary and middle schools are reported because there was no FCAT 2.0 Mathematics assessment administered at the high school level. A repeated measures ANOVA was conducted to compare the main effects of student grade level, SES, and gender and the interaction effect between grade level, SES, and gender on student FCAT 2.0 Mathematics DSS. Student grade level included six levels, SES included two levels, and gender included two levels.

As can be seen in Table 38, the assumption of homogeneity of variance was tested and satisfied via Levene's F test, F(4450) = .765, p = .779. The repeated measures ANOVA was used to compare the mean change in FCAT 2.0 Mathematics DSS from 2012-2013 to 2013-2014. The same students attending DCPP schools were measured before and after program implementation. Table 39 shows the assumption of sphericity for the main effect was satisfied, F(1, 4450) = 2.425, p = .117.

As can be seen in Table 40, there was no statistically significant difference between mean FCAT 2.0 Mathematics DSS scores for 2012-2013 and 2013-2014, F(1) = 2.452, p = .117. Table 41 shows mean FCAT 2.0 Mathematics DSS for 2012-2013 (M = 224.4, SE = .5) and 2013-2014(M = 225.6, SE = .6). Although no statistically significant difference was found between the baseline year and the first year of DCPP implementation, Roy's Largest Root shows a significant interaction between FCAT 2.0 Mathematics and grade level, FCAT 2.0 Mathematics and SES, and FCAT 2.0 Mathematics, grade level, and SES (see Table 40).

As can be seen in Table 42, student grade level and SES were statistically significant at the .05 significance level; no other effects were statistically significant. The main effect for grade level yielded an F ratio of F(5, 4450) = 164.61, p = .000, indicating a significant difference between third grade (M = 209.9, SE = 1.2), fourth grade (M = 215.8, SE = 1.4), fifth grade (M = 221.6, SE = 1.2), sixth grade (M = 229.2, SE = 0.6), seventh grade (M = 234.9, SE = 0.5), and eighth grade (M = 238.6, SE = 0.5). Although no statistically significant difference was found between the baseline year and the first year of DCPP implementation, there was a significant interaction effect for grade level and SES, but no interaction effects between subjects (see Table 42). Table 43 shows mean scores with 95% confidence interval for FCAT 2.0 Mathematics DSS by grade level.

Table 38: Levene's Test of Equality of Error Variances for FCAT 2.0 Mathematics

	F	*df1*	*df2*	*p*
FCAT2012	1.842	23	4450	.008
FCAT2013	.765	23	4450	.779

Table 39: Tests of Within-Subjects Effects for FCAT 2.0 Mathematics

Source		*SS*	*df*	*MS*	*F*	*p*	Partial Eta Squared
FCAT	Sphericity Assumed	1168.013	1	1168.013	2.452	.117	.001
	Greenhouse-Geisser	1168.013	1.000	1168.013	2.452	.117	.001
	Huynh-Feldt	1168.013	1.000	1168.013	2.452	.117	.001
	Lower-bound	1168.013	1.000	1168.013	2.452	.117	.001

Table 40: Multivariate Tests for FCAT 2.0 Mathematics

Effect		*Value*	*F*	*Hypothesis df*	*Error df*	*p*	Partial Eta Squared
FCAT	Pillai's Trace	.001	2.452	1.000	4450.000	.117	.001
	Wilks' Lambda	.999	2.452	1.000	4450.000	.117	.001
	Hotelling's Trace	.001	2.452	1.000	4450.000	.117	.001
	Roy's Largest Root	.001	2.452	1.000	4450.000	.117	.001

Table 41: Mean Differences for FCAT 2.0 Mathematics
2012-2013 and 2013-2014

			95% Confidence Interval	
FCAT	*M*	*SE*	Lower Bound	Upper Bound
1	224.420	.487	223.466	225.375
2	225.633	.605	224.447	226.819

Table 42: Tests of Between-Subjects Effects
for FCAT 2.0 Mathematics

Source	*SS*	*df*	*MS*	*F*	*p*	Partial Eta Squared
Intercept	160937277.456	1	160937277.456	334054.525	.000	.987
GRADE_LVL	396509.256	5	79301.851	164.605	.000	.156
SES	20019.101	1	20019.101	41.553	.000	.009
GENDER	1652.560	1	1652.560	3.430	.064	.001
GRADE_LVL * SES	4315.254	5	863.051	1.791	.111	.002
GRADE_LVL * GENDER	3377.334	5	675.467	1.402	.220	.002
SES * GENDER	108.319	1	108.319	.225	.635	.000
GRADE_LVL * SES * GENDER	778.385	5	155.677	.323	.899	.000
Error	2143874.220	4450	481.769			

Table 43: FCAT 2.0 Mathematics DSS by Grade Level

			95% Confidence Interval	
Grade Level	*M*	*SE*	Lower Bound	Upper Bound
3	209.919	1.167	207.630	212.207
4	215.834	1.387	213.115	218.553
5	221.645	1.188	219.315	223.974
6	229.197	.556	228.108	230.286
7	234.923	.465	234.011	235.834
8	238.642	.484	237.694	239.590

The main effect for SES yielded an F ratio of F(1, 4450) = 41.6, p = .000, indicating a statistically significant difference between students receiving free or reduced lunch and students not receiving free or reduced lunch (see Table 42). As can be seen in Table 44, students with lower SES classifications scored lower (M = 222.5, SE = 0.3) on the FCAT 2.0 Mathematics than students with higher SES classifications (M = 227.5, SE = 0.7). The main effect for gender yielded an F ratio of F(1, 4450) = 3.430, p > .05, indicating that the effect for gender was not significant; male students (M = 225.7, SE = 0.5) scored nearly the same as female students (M = 224.3, SE = 0.6). The interaction effects of grade level and SES; grade level and gender; SES and gender; and grade level, SES, and gender were all not statistically significant (See Table 42).

Table 44: FCAT 2.0 Mathematics DSS by SES

			95% Confidence Interval	
SES	*M*	*SE*	Lower Bound	Upper Bound
No FRL	227.536	.718	226.128	228.945
FRL	222.517	.301	221.928	223.106

In addition to the repeated measures ANOVA used to analyze the effects of one-to-one initiatives on student DSS on the FCAT 2.0 Mathematics by gender, grade level, and SES, a factorial ANCOVA was conducted in order to find out more about the effects one-to-one initiatives had on students at the different school levels—elementary, middle, and high school.

As can be seen in Table 45, the assumption of homogeneity of variance was tested and satisfied via Levene's F test, F(4472) = 1.066, p = .302. The factorial ANCOVA was associated with a statistically significant effect, F(1, 4470) = 4.575, p = .032. The mean difference in growth in FCAT 2.0 Mathematics DSS was statistically significant between elementary and middle schools. As can be seen in Table 46, middle school students (M = 229.5, SE = 0.4) showed larger mean growth in FCAT 2.0 Mathematics DSS than elementary school students (M = 221.7, SE = 1.1). Although the main effect was statistically significantly different, the interaction effect between school level and DSS was not statistically significant, F(2, 4470) = 2.258, p = 0.105. Table 47 shows tests of between-subject effects for FCAT 2.0 Reading.

Table 45: Levene's Test of Equality of Error Variances for FCAT 2.0 Mathematics ANCOVA

	F	*df1*	*df2*	*p*
FCAT2013	1.066	1	4472	.302

Table 46: FCAT 2.0 Mathematics DSS by School Level

			95% Confidence Interval	
School Level	*M*	*SE*	Lower Bound	Upper Bound
Elementary	221.690[a]	1.052	219.629	223.752
Middle	229.519[a]	.438	228.660	230.378

a. Covariates appearing in the model are evaluated at the following values: FCAT2012 = 230.00.

Table 47: Tests of Between-Subjects Effects
for FCAT 2.0 Mathematics ANCOVA

Source	*SS*	*df*	*MS*	*F*	*p*	Partial Eta Squared
Corrected Model	75040.514[a]	3	25013.505	42.913	.000	.028
Intercept	1515064.793	1	1515064.793	2599.212	.000	.368
School level	2666.881	1	2666.881	4.575	.032	.001
School level * FCAT2012	2632.566	2	1316.283	2.258	.105	.001
Error	2605535.438	4470	582.894			
Total	233997406.000	4474				
Corrected Total	2680575.952	4473				

a. R Squared = .028 (Adjusted R Squared = .027)

Summary

This chapter began with an introduction of the statistical tests and analyses that were to be discussed and in what order they would be presented. This was followed by an analysis of student achievement variables and student demographic data.

Results from the first research question revealed differing results based on school level. Elementary school students who received traditional modes of instruction performed better on the FCAT 2.0 Reading than students who received one-to-one instruction. On the other hand, middle school students who received one-to-one instruction fared better on the FCAT 2.0 Reading than students who received traditional modes of instruction. There was no statistically significant difference in FCAT 2.0 Reading DSS between high school students who received one-to-one instruction and those who received traditional modes of instruction.

Results from the second research questions were also mixed. There was no statistically significant difference in FCAT 2.0 Mathematics DSS between elementary school students who received one-to-one instruction and those who received traditional modes of instruction. On the other hand, middle school students who received one-to-one instruction performed better on the FCAT 2.0 Mathematics than students who received traditional modes of instruction.

Results from the third research question revealed no statistically significant difference in student FCAT 2.0 Reading DSS before program implementation and after the first year of program implementation. However, the results also revealed differences in student DSS based on student grade level and SES, with higher scores being generally associated with higher grade levels and higher SES.

Results from the final research question also revealed no statistically significant difference in student FCAT 2.0 Mathematics DSS before program implementation and after the first year of program implementation. Likewise, the results also revealed differences in student DSS based on student grade level and SES, with higher scores being generally associated with higher grade levels and higher SES. The next chapter will include a discussion of the findings reported in this section, implications for practice, and recommendations for future research.

CHAPTER V: DISCUSSION

Introduction

The preceding chapter included a presentation and analysis of the data. Chapter V consists of a summary of the study, discussion of the findings, implications for practice, recommendations for further research, and conclusions. The purpose of this final chapter is to delve further into the concepts analyzed in this study in order to provide further understanding of the effects of one-to-one digital instruction on student achievement, and to present suggestions for further research on technology in the classroom. Finally, a concluding statement is provided to synthesize the scope and substance of the study.

Summary of the Study

The purpose of this study was to examine the effects of one-to-one computer initiatives on student achievement on standardized assessments in reading and mathematics. This study compared the FCAT 2.0 Reading and Mathematics DSS of students attending DCPP schools with those of students attending comparison schools implementing traditional modes of instruction. A second purpose of this study was to determine what effects one-to-one initiatives had on student achievement overall, by grade level, gender, and socio-economic status (SES).

Although this study examined student achievement using only archival data, this section will attempt to analyze student learning in one-to-one environments through connectivism theory. One major objective of one-to-one initiatives cited in much of the literature is to build

21st century skills in students along with improving academic achievement and preparing students for the workforce. Connectivism theory accounts for social contexts (i.e. 21st century skills) in its views of learning and seeks to define learning from a more pragmatic perspective. Although this study does not include qualitative data regarding the types of instruction used in DCPP schools, and therefore cannot truly discuss the how connectivism impacted student learning, connectivism assists in discussing implications for practice and should be considered as a framework from which to conduct future research regarding one-to-one initiatives. Connectivism shifts the role of teachers from keepers of knowledge to facilitators of learning, and the focus of learning from knowing information to knowing how to find information. Connectivism theory helps to explain how learning takes place for students who learn under the conditions set forth in the one-to-one initiatives.

This study included 16,188 students who received scores on the FCAT 2.0 Reading for the 2013-2014 school year; 5,637 attended DCPP schools and 10,511 attended randomly selected comparison schools. The students were further divided by school level; 3,166 students attended elementary schools, 9,256 attended middle schools, and 3,766 attended high schools. A demographic breakdown was provided for grade level, gender, and SES. This study included four research questions:

1. What is the difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction?

2. What is the difference in FCAT 2.0 Mathematics scores between students in elementary and middle schools implementing one-to-one initiatives and students receiving traditional modes of instruction?
3. What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?
4. What is the difference in student academic achievement growth in FCAT 2.0 Mathematics scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender?

Questions one and two were answered from the school district archival data for the school years 2012-2013 and 2013-2014. Question one was answered using the results from an independent-samples t-test comparing DSS from DCPP schools and comparison schools on the FCAT 2.0 Reading. Question two was answered using the results from an independent-samples t-test comparing DSS from DCPP schools and comparison schools on the FCAT 2.0 Mathematics. To answer question three, a repeated measures ANOVA was performed to compare the main effects of student grade level, SES, and gender and the interaction effect between grade level, SES, and gender on student FCAT 2.0 Reading DSS. Question four was also answered using a repeated measures ANOVA to compare the main effects of student grade level, SES, and gender and the interaction effect between grade level, SES, and gender on student FCAT 2.0 Mathematics DSS. Additionally, a factorial ANCOVA was conducted for questions three and four in order to find out more about the effects of one-to-one initiatives by school level.

Discussion of the Findings

During the last two decades, researchers (Dunleavy & Heinecke, 2008; Lee et al., 2011; Liao, Chang, and Chen, 2008; Mouza, 2008; Penuel, 2006; Rockman, 2003; Roschelle et al., 2000; Russell, Bebell, & Higgins, 2004; Tamim et al., 2011) have found mixed results regarding the effects of one-to-one computer initiatives on student academic achievement. The goal of this study was to compare student achievement at one-to-one schools to student achievement at traditional schools, as well as to compare student achievement at one-to-one schools by gender, grade level, and SES. This section discusses the implications of the findings for each of the four research questions.

Research Question 1

Question 1: What is the difference in FCAT 2.0 Reading scores between students in elementary, middle, and high schools implementing one-to-one initiatives and students receiving traditional modes of instruction? Like the overall results of this study, the findings from research question one were mixed. The findings show that elementary school students who attended DCPP elementary schools scored lower on the FCAT 2.0 Reading than students who attended comparison schools. Conversely, students who attended DCPP middle schools scored better than students who attended comparison schools. There was no statistically significant difference in FCAT 2.0 Reading between students who attended DCPP high schools and students who attended comparison schools. The differences in student scores for students who attended DCPP schools and those who attended comparison schools, although significant, were small both for elementary and middle schools.

These findings are in line with studies that reported no difference or slight declines in student achievement during the first year of one-to-one program implementation (Penuel, 2006). These results can be attributed in part to difficulties transitioning from traditional modes of instruction for both teachers and students—teachers must learn how to fully utilize ubiquitous technology to plan and implement lessons, and students must learn how to use the tools responsibly and efficiently. Additionally, schools must adapt to the new infrastructure requirements, respond to unforeseen technical issues, and create new types of professional development for teachers. Adjusting to technology in the classroom likely had an effect on the overall learning gains of the students in this study as teachers were required to spend time teaching technology skills when they would likely have been teaching content. This is one possible explanation for the modest results found in this study.

Research Question 2

Question 2: What is the difference in FCAT 2.0 Mathematics scores between students in elementary and middle schools implementing one-to-one initiatives and students receiving traditional modes of instruction? Like research question one, research question two revealed mixed results. Elementary school students who attended DCPP elementary schools scored lower on the FCAT 2.0 Mathematics than students who attended comparison schools. Again, students who attended DCPP middle schools scored higher than students who attended comparison schools. The difference in student scores for students who attended DCPP schools and those who attended comparison schools, although significant, were small. For elementary schools, the average FCAT 2.0 Mathematics DSS for DCPP schools was 208.9, compared to 210.1 for comparison schools. The difference in FCAT 2.0 Mathematics DSS for middle school students was higher—236.3 for DCPP middle schools, compared to 232.8 for comparison schools.

These findings are once again in line with previous research indicating mixed results (Penuel, 2006). Because this study was conducted after only the first year of implementation, the same factors that influenced research question one likely influenced the results of research question two. Additionally, the results from research question one and two, when analyzed together, reveal a difference between elementary and middle schools. For both assessments—FCAT 2.0 Reading and FCAT 2.0 Mathematics—elementary school students at DCPP schools scored lower on average than elementary school students at comparison schools. Conversely, middle school students at DCPP schools scored higher on average than middle school students at comparison schools on both the FCAT 2.0 Reading and FCAT 2.0 Mathematics. These findings are in line with much of the literature that suggest one-to-one initiatives have a greater impact on middle school student achievement than elementary or high school student achievement (Kobelsky, Larosiliere, & Plummer, 2013; Penuel, 2006).

Research Question 3

Question 3: What is the difference in student academic achievement growth in FCAT 2.0 Reading scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender? The findings from research question three revealed no significant difference in student FCAT 2.0 Reading DSS before and after program implementation. In other words, students did not score significantly different after one year of one-to-one instruction than they had scored the previous year. The average FCAT 2.0 Reading DSS for students before one-to-one instruction was 227.0 compared to 225.9 after one-to-one instruction. Although there was no statistically significant difference for overall academic achievement growth, there were interaction effects between student scores, grade level, and SES. Generally, higher grade-level (until middle school) and SES were associated with higher FCAT 2.0 Reading DSS.

After only one year of implementation, the results of this study suggest that one-to-one initiatives were more effective for students in the middle grades and for students from higher SES homes. A possible reason for the overall lower effect of one-to-one initiatives on students from low SES households is student access to technology. Students from lower SES homes have limited access to technology and internet connectivity, which likely influenced their first experience with one-to-one instruction adversely. In order to examine further the effects of one-to-one initiatives by grade level, a factorial ANOCOVA was conducted. The results of this test demonstrated no statistically significant difference in student FCAT 2.0 Reading DSS between elementary, middle, and high school students. These findings contradict much of the literature and the results from the previous statistical tests that were run in this study.

Research Question 4

Question 4: What is the difference in student academic achievement growth in FCAT 2.0 Mathematics scores for students receiving one-to-one computer instruction by grade level, socio-economic status, and gender? The findings from the final research question revealed no significant difference in student FCAT 2.0 Mathematics DSS before and after program implementation. In other words, students did not score significantly different after one year of one-to-one instruction than they had scored the previous year. The average FCAT 2.0 Mathematics DSS for students before one-to-one instruction was 224.4 compared to 225.6 after one-to-one instruction. Although there was no statistically significant difference for overall academic achievement growth, there were interaction effects between student scores, grade level, and SES. Generally, higher grade-level and SES were associated with higher FCAT 2.0 Mathematics DSS.

These findings are in line with the findings from question three suggesting students from lower SES homes had more difficulty adjusting to the technology, likely due to technology access at home. However, the results for grade level were not the same for questions three and four. The factorial ANCOVA revealed statistically significant differences between elementary and middle school student growth for students at DCPP schools. The mean difference in growth in FCAT 2.0 Mathematics DSS was statistically significantly higher for middle schools than elementary schools.

Overall, the results are in line with much of the literature over the past two decades. One-to-one programs have been studied with mixed results based on a number of factors; i.e. implementation practices, professional development, funding, student demographics, length of time using intervention, etc. The major confounding factor affecting this study was length of time using the intervention. This study found what has been reported in other studies (Penuel, 2006) regarding student achievement at one-to-one schools; no gain or a slight decrease in student scores on assessments. In opposition to the majority of the literature on this subject, this study found slightly positive effects in mathematics and slightly negative effects in reading.

Implications for Practice

Although school accountability is regularly at the forefront of education policy lately, it is not a new issue in education. For decades, school accountability has been a highly discussed topic in education. When one-to-one initiatives entered the education scene in the 1990s, and as it has evolved in recent years, it did so under the scope of school accountability. That is, the evaluation of its failure or success has depended on overall student performance on standardized tests. Over the years, studies have found both in favor of and against one-to-one initiatives as a successful educational intervention. However, one-to-one initiatives are about more than simply raising student test scores.

As discussed in previous chapters, school districts implementing one-to-one initiatives have several listed objectives in addition to raising student scores. These include (1) eliminating computer labs; (2) improving academic achievement; (3) improving equity of access; (4) more effectively preparing students for the workforce; (5) transforming the quality of instruction; and (6) increasing economic benefits (Penuel, 2006; Topper & Lancaster, 2013). Student academic achievement and one-to-one computers do not necessarily have to be linked together. Computers are simply tools that can be used to deliver, facilitate, and assess learning, not tools that inherently improve learning. Computers should not be seen as a magic intervention that will make students smarter, but they should be viewed as a necessary tool that students should learn how to master if they are to be college and career ready by the time they graduate high school.

The results of this study mimic much of the research available over the past two decades; mixed or minor differences in student test scores. However, it should be noted that this study was conducted during the first year of implementation; a transition time when it is reasonable to expect students and teachers to struggle as they learn new ways of teaching and learning with digital tools. Still, some of the findings can be used to inform practice.

Research questions one, two, and four found that students in middle school generally received the most benefit from one-to-one instruction. It is possible that students in elementary school are too young or have not developed the technology skills necessary to utilize the computers to their full potential. It is necessary to conduct qualitative research to analyze the different ways elementary and middle school teachers use technology in the classroom. This finding, which aligns with much of the literature, can be helpful for schools or school districts thinking about implementing one-to-one initiatives. Knowing which school levels are likely to yield the best results from one-to-one initiatives can help school districts better allocate limited funds.

Another relevant finding from questions three and four that can help inform practice is the effects of one-to-one initiatives on students from lower SES homes. This study found that one-to-one initiatives had a decreased effect on students from lower SES homes. This is relevant information for schools that serve lower SES communities and are interested in adopting one-to-one programs. This finding delineates the importance of preparing students—particularly those who do not have rich access to technology at home—for one-to-one instruction. Teachers at one-to-one schools should be prepared to not only teach their standards, but also technology skills to those students who may be deficient.

Recommendations for Further Research

The goal of this study was to investigate the effects of one-to-one computer initiatives on student academic achievement on standardized assessments. Data was collected and analyzed to answer the four research questions relating to this goal. The findings of this study were mixed and generally not statistically significant. One major limitation to this study was the length of the intervention. Much of the research states that one-to-one initiatives generally find little or no change in student academic achievement after the first year of implementation; this study confirms those findings. Future research should analyze the effects of long-term implementation.

Other factors that could have affected this study are: (1) differences in teacher effectiveness by school; (2) differences in implementation practices by school; (3) frequency of usage by school; (4) professional development by school; and (5) educational philosophy by school. Future research should combine qualitative and quantitative methods to study the abovementioned factors in addition to student achievement for schools implementing one-to-one initiatives.

Building 21st century skills is an important objective of schools; however, the findings of this research study along with much of the literature which demonstrate mixed results raise the question, "does every student need a computer in order to learn 21st century skills?" More research should be conducted to determine student attainment of 21st century skills for various student-to-computer ratios in the classroom.

Teacher effectiveness is another confounding factor which has been shown to directly impact student academic achievement. Future studies should look to analyze the effects of one-to-one initiatives on student achievement based on teacher evaluations. It is worth examining whether students with highly effective teachers experience greater learning gains from one-to-one instruction than students with teachers that receive lower effectiveness ratings.

Finally, the differing effects of one-to-one initiatives by school level should be examined more closely. This study, in agreement with the literature, found that middle school students experienced the highest increases in learning gains from one-to-one programs. Research should be conducted to determine what factors make middle schools more ideal for one-to-one digital instruction than elementary or high schools. Additionally, studies that analyze student scores on standardized tests and qualitative factors such as quantity and quality of professional development, frequency and type of laptop use by teachers, and school educational philosophy should be conducted to determine the ideal contexts under which one-to-one initiatives can thrive.

Conclusions

The findings of this study expanded the work of previous researchers in the area of ubiquitous computing in education. This investigation revealed mixed results on student academic achievement based on whether or not they received one-to-one digital instruction. Elementary school students who attended DCPP schools scored lower on average in reading and mathematics than elementary school students who attended comparison schools. On the other hand, middle school students who attended DCPP schools scored higher on average in reading and math than middle school students who attended comparison schools. There was no statistically significant difference between DCPP schools and comparison schools at the high school level.

A further examination of student achievement at DCPP schools demonstrated a differing effect of one-to-one instruction on student achievement by grade level and SES. Students in higher grade-levels and from higher SES homes generally showed greater learning gains than students from lower grade levels and SES homes. Lastly, and possibly most poignantly, in both reading and mathematics, there was no statistically significant difference in student achievement before program implementation and after.

As technology has become ubiquitous in society, schools have sought to keep up by making it ubiquitous in the classroom as well. Although one-to-one initiatives nationwide list many objectives in addition to student academic achievement, student learning will likely continue to be the lens from which one-to-one initiatives is assessed. Although this study revealed mixed results, much of the literature supports benefits, including academic achievement, from one-to-one initiatives. It is unlikely that one-to-one initiatives will fade due to mixed results; it is more likely that they will continue to evolve and become an integral part of school systems nationwide. Therefore, it is imperative to continue to study ubiquitous computing initiatives in order to find best practices for the future.

APPENDIX: IRB APPROVAL LETTER

University of Central Florida Institutional Review Board Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1 FWA00000351, IRB00001138**

To: **Fernando Lobeto**

Date: **June 23, 2015**

Dear Researcher:

On 06/23/2015, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Ubiquitous Computing in Public Education: The Effects of One-to-One Computer Initiatives on student achievement on Florida Standardized Assessments
Investigator:	Fernando Lobeto
IRB Number:	SBE-15-11380
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator

Manual. On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Joanne Muratori

Signature applied by Joanne Muratori on 06/23/2015 03:12:06 PM EDT

IRB manager

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