DISSERTATION

ONE-TO-ONE LAPTOPS IN A PUBLIC SECONDARY SCHOOL:

STUDENTS' USAGE AND THE IMPACT ON ACHIEVEMENT

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ABSTRACT

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Computer technology has become ubiquitous in the lives of today's learners. Schools and districts are responding to the rise of technology with a push to expand access to computers for all students in the form of one-to-one laptop initiatives. While such initiatives have been shown to help students develop computer and technology skills, their impact on achievement has been more difficult to ascertain. Differences in implementation levels between different schools, teachers, and students, have made the relationship between laptop use and achievement difficult to measure. This study was designed to provide more information regarding the relationship between different types and frequencies of laptop usage and student reading achievement, as well as the barriers and opportunities which limit or promote the use of the laptops by students and teachers.

This study used a mixed methods design incorporating both qualitative and quantitative data and analysis. Three hundred and fifty-five 9th and 10th grade students at a public high school which was in the fifth year of a one-to-one laptop initiative were surveyed regarding the specific ways in which they used their district-provided laptop computers. These findings were matched with individual achievement scores on the MAP reading test and statistical correlations were run between specific types and frequencies of laptop use and achievement. In addition, three teachers were interviewed regarding the barriers to the use of the laptops they had faced and the resources and skills which enabled their successful integration.

The quantitative findings of the study indicate that using the laptops for homework and outside the classroom learning are significantly correlated with high reading achievement. They also indicate that activities such as social networking, playing games, and contributing to online databases were significantly correlated with low reading achievement. The qualitative findings showed that student lack of access to Wi-Fi at home, the ability level of students, and specific content-area concerns were significant barriers to the incorporation of the laptops into the learning process. They also indicated that ongoing professional development and teacher perseverance were keys to the successful integration of the laptop computers into the teaching and learning process.

TABLE OF CONTENTS

Chapter 1: Introduction……………………………………………………………………… 1

Need for the Study……………………………...………………………………..…………2

Significance of the Study……………………………………………………………….. 6

Research Questions……………………………………………………..…………. 9

Purpose of the Study…………………………………………………...………...9

Researcher's Perspective………………………………………………………...…… 10

Definitions………………...………………………………………………………….. 10

Delimitations…………………………………………………………………………. 12

Limitations……………………………………………………….……………...13

Assumptions………………………………………………………………..………… 14

Chapter 2: Review of Literature………………………..……………………………….…… 16

Twenty-first Century Skills……………………………………………………………... 17

Student-centered Learning………………...…………………………………………. 20

Individualized Learning……………..…………………………………………….. 22

The Digital Divide………………..…………………………………..……….....22

Classroom Discipline………………………………………………………………… 26

Student Engagement…………………………………………………………………..28

Student Organization……………...…………………………………………………..30

Standardized Testing……….………………………………………………………… 31

Lack of Achievement Data……………………………………………………………33

Mixed Achievement Results……………………………….…..…………………. 36

Evidence of Achievement Benefits 38
Frequency of Use and Achievement 38
Math achievement 39
Writing achievement 40
Reading achievement 41
Science Achievement 42
Achievement Gap 42
Achievement Gap Worse 43
Achievement Gap Better 44
Twenty-Four Hour Access 45
Issues in Implementation 46
Implementation Gap 46
Differences in Teacher Implementation 47
Differences in Building Implementation 48
Factors Influencing Implementation 49
Technology, Pedagogy, and Content Knowledge 52
Professional Development 53
Chapter 3: Methodology 56
Research Paradigm 56
Research Design 69
Research Setting 71
Sampling 72
Data Collection 73

Validity and Reliability…………………………………………………………………. 73

Data Analysis…………………………………………………………..………….. 75

Chapter 4: Findings…………………………………………………………..……… 77

Descriptive Statistics……………………………………………………………………78

Between Groups Comparisons……………………………………………………….. 80

Correlations………………………………………………………………………... 81

Multiple Regressions……………………………………………………………………85

Qualitative Findings…………………………………………………………………….. 90

Ability Level and Homework ………………………………………..…….92

Solutions for the Lack of Access at Home……………………….…………... 94

Barriers and Drawbacks…………………...………………………………… 96

Software and Hardware Availability……...……………………………..96

Waste of Class Time……………………..……………………………97

Students not Bringing Laptops to Class……..…………………………... 98

Teachers' Reluctance to Use the Laptops…………...………………….. 99

Content Area Concerns………………………………………… 100

Grade and Ability Level………………………………………...100

Confusing Nature of Technology……………………………….101

Opportunities and benefits………………………………………………... 102

Standardized test preparation.…………………………………………..102

Preparation for the future……………………………………………. 103

Organizational benefits………………………………………………… 104

Perseverance……………………………………………………………………… 105

Professional development………………………………………………………… 107

Chapter 5: Discussion………………………………………………………………………. 114

Study Summary……………………………………………………………………114

Need for the Study……………………………………………………….... 115

Method………………………………………………………………………. 116

Research Questions…………………………………………………….….116

Discussion of Findings………………………………………………………… 117

Types and Frequencies of Laptop Usage………………………………………. 117

Types of Use Correlated with High Reading Achievement …….……...………120

Types of Use Correlated with Low Reading Achievement …........……………. 122

In-class Use of Laptops and Reading Achievement …………….……..………… 123

Predicting Low Reading Achievement…….…………………………………..…. 123

Predicting High Reading Achievement…………………………………...…… 124

Resources and Skills Which Promote Teacher Use of Laptops………...………125

Barriers and Obstacles to Teacher Use of Laptops……………..……………… 127

Comparisons Between Qualitative and Quantitative Data……………………...130

Internet access at home…………………………………………………… 130

Use of Laptops in math classes…..……………………….…………. 132

Use of laptops and reading achievement………………….……...……. 132

Recommendations for Practice………………………………………...………….. 133

Recommendations for Further Research………………………………………..136

Final Thoughts……………………………………………………………...…….. 137

References...……………………………………………………………………….139

Appendices……………………………………………………………………...154

Appendix A: Teacher Consent to Participate……………………………………………..155

Appendix B: Teacher Interview Protocol……………………………………………... 157

Appendix C: Parental Consent to Participate…………………………………………..158

Appendix D: Student Consent to Participate………………………………………….. 159

Appendix E: Student Survey…………………………………………………………...160

Appendix F: Student Participant Recruitment Script…………………………………..162

Appendix G: District Approval to Conduct the Study…………………………………163

Appendix H: Principal Approval to Conduct the Study………………………………. 164

Appendix I: Colorado State University IRB Approval………………………………...165

CHAPTER ONE: INTRODUCTION

Today's students are the first generation of young people to have lived their entire lives in a society shaped by computer technology, and unlike previous generations, they will never experience a world without it (Niles, 2006). For this new generation of teachers and students technology is an essential and integral part of everyday life (Fleischer, 2012; Gorder, 2007; Jett, 2013). This new reality has fundamentally changed the way this generation thinks, conducts research, and communicates. In fact, the changes brought about by the expansion of the Internet into the very fabric of our society are comparable in significance to those brought about by the invention of the printing press in the 15^{th} century (Kuttan & Peters, 2003). It has become abundantly clear that integrating technology into our classrooms is essential to keep pace in our interconnected global economy and that students must have strong technology and media literacy as they enter the workforce (Friedman, 2007). Unfortunately, these fundamental changes in the way we communicate, find and share information, collaborate, and entertain ourselves have happened so quickly that educators and education leaders have found themselves struggling to keep up with the need for the rapid integration of new hardware and software into educational practice and the classroom (Fleischer, 2012).

The desire to integrate technology into the classroom to meet the demands of today's student has resulted in countless technology initiatives in schools around the world. It has quickly become clear, however, that simply buying hardware and distributing it to teachers and students is not enough to ensure the meaningful integration of technology into the classroom to enhance student learning and achievement (Ball, 2010; Goodwin, 2011; Harris, 2010; Jett, 2013; Warschauer, Zheng, Niiya, Cotten, & Farkas, 2014). Because changes have happened so quickly and technology initiatives have been implemented so rapidly, our understanding of the barriers and opportunities for effective integration of technology into the classroom and the effect of such implementation on student achievement are still developing (Fleischer, 2012). The challenge that faces education researchers is to understand how ubiquitous technology initiatives like one-to-one laptop programs are being implemented (or not being implemented) by teachers, how technology in such initiatives is being utilized by students, and in turn how those practices are impacting student achievement.

Need for the Study

While a large number of studies have been conducted on one-to-one laptop initiatives, there has been relatively little research exploring the connection between laptop initiatives and student achievement (Suhr, Hernandez, Grimes, & Warschauer, 2010). Existing studies have tended to focus on outcomes such as the development of technical skills and computer expertise, not on student achievement in particular (Storz & Hoffman, 2013). In addition, a recent review of the literature on one-to-one initiatives found that the evidence connecting one-to-one initiatives to achievement is weak and inconclusive (Fleischer, 2012). This demonstrates a clear need for a systematic, empirical evaluation of a laptop program which focuses specifically on its impact on student achievement.

Studies which focus on the achievement impact of a one-to-one laptop initiative on a district or school as a whole may provide mixed results due to different levels of implementation and usage between both the teachers and students participating in that initiative. Variations in implementation and the level of integration of laptops into the learning process by different teachers and students make it highly problematic to expect changes on standardized test scores to be reflected at the building or district level, but there is some preliminary evidence to support the claim that if measurements are based on individual student usage levels such impacts could be more clearly discerned (Silvernail & University of Southern Maine, 2005; Spires, Oliver, & Corn, 2012). For example, a study of a laptop initiative in Texas showed mixed results on student achievement in general but showed that among students who used the laptops the most frequently reading and math scores on standardized tests were significantly higher. Another study in Virginia also showed that the students who used their laptops the most frequently had higher standardized test scores, leading Abell Foundation (2008) researchers to conclude that higher usage rates may be correlated with increased academic gains.

A statistical meta-analysis of ten empirical studies of one-to-one laptop programs revealed statistically significant correlations between laptop programs and achievement in English, writing, math, and science, but did not find a statistically significant difference in reading scores between participants in such programs and comparison groups (Zheng, Warschauer, Lin, & Chang, 2016). However, the authors cite two additional studies which considered student usage of the laptops, one of which found that using the laptops for at-home learning strongly predicted reading achievement scores (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010) and another which found a positive correlation between the frequent use of laptops for learning at home and reading achievement scores (Kay, 2010). These findings indicate that simply providing laptops to students does not appear to positively impact reading achievement, but that specific types and frequencies of usage can be indicators of high reading scores.

It should be noted, however, that the results of a meta-analysis of effect sizes in education research are potentially problematic. A study of 645 quantitative studies in prekindergarten-12 education which sought to measure the effect of an intervention on reading, math, or science achievement found significant differences between the effect sizes of studies based on their methodological features (Cheung & Slavin, 2016). They found, for example, that smaller studies had effect sizes which were twice as large as studies with *n*-values over 250. They also found that the effect sizes in published papers were nearly twice as large as those in unpublished papers, and that quasi-experimental studies had significantly higher effect sizes than those with randomized assignment to groups. These findings lead Cheung and Slavin (2016) to recommend that researchers need to take into consideration such factors when comparing effect sizes from program evaluations. Because the meta-analysis conducted by Zheng et al. (2016) does not differentiate between the ten studies' sample size, whether they were randomized vs. quasi-experimental designs, and drew only from journal-published studies and dissertations (excluding conference papers and reports which had not been peer-reviewed) it's results do not appear to meet the recommendations of Cheung and Slavin (2016) regarding their criterion for reliable effect size comparison. This means that the findings of the meta-analysis, while interesting and potentially somewhat informative, are problematic and should not be considered conclusive.

There is a need for further studies which examine the impact of laptops on student reading achievement, taking into account the extent of individual teacher and student use of the laptops, if we are to obtain a thorough understanding of the relationship between laptop use and student achievement (Weber, 2012). The time has come to begin to determine whether the mixed results of research into the impact of one-to-one initiatives on reading achievement are the result of varying levels of implementation and use among individuals within such initiatives, so that a clearer picture of the relationship between ubiquitous technology and increased achievement can be more clearly ascertained. This study of correlations between reported levels of usage by students and teachers and student reading achievement was specifically designed to fill that need.

In addition, the evidence of the impact of one-to-one laptop initiatives on student reading achievement in particular is very limited. A comprehensive review of the literature on one-to-one laptop programs found only two studies which provide evidence of a correlation between such programs and increased student reading achievement (Rosen & Beck-Hill, 2012; Suhr, Hernandez, Grimes, & Warschauer, 2010), one study which produced mixed results (Hoyer, 2011), two studies which showed small but not significant gains in reading scores (Bird, 2009; Bryan, 2011), and another which, alarmingly, showed a significant drop in student reading and language arts scores after the implementation of a one-to-one computing program, prompting the researcher to call for more specific investigations into the implementation of laptop programs by teachers to better understand their impact (Burgad, 2008). This body of evidence is very limited and is based almost entirely on evidence from immature laptop programs which were in their first (Bird, 2009; Bryan, 2011; Burgad, 2008) or second year (Hoyer, 2011; Rosen & Beck-Hill, 2012; Suhr et al., 2010) of implementation. However, data from a laptop immersion project in Texas showed achievement gains did not begin to appear until the third year of implementation (Abell Foundation, 2008), giving us reason to believe that studies of immature laptop initiatives may have been inconclusive because they were conducted when those initiatives were in their early stages – before those programs had time to be fully integrated by teachers and students into the learning process. This study meets the need for a more thorough examination of the possible correlations between reading achievement and the level of use by students in a laptop program which was in its fifth year of implementation at the time of the study, giving it sufficient time to be fully established among teachers and students at the participating school and for possible achievement gains to have had sufficient time to emerge.

Significance of the Study

Since the groundbreaking implementation of the Maine Learning Technology Initiative, which was a seminal large scale one-to-one laptop initiative launched statewide in 2002 (Waters, 2009), schools and school districts around the world have been inspired by its example and have rolled out numerous one-to-one laptop initiatives. These initiatives are described as an effort to get a laptop computer into the hands of each and every student (Fleischer, 2012). By the year 2006 as many as 24% of school districts reported they had implemented or were in the process of implementing a one-to-one technology program (Abell, 2008; Borja, 2006) and by the year 2010 that number had increased to 37% (Nagel, 2010) and by early 2015 education technology industry analysts were saying that more than half of American students and teachers would be using a school-provided personal computer in the 2015/2016 school year (Molnar, 2015). In addition, recent data shows that access to technology has become amazingly ubiquitous with 89% of high school students having access to a smart phone, 66% having access to a laptop, and 50% having access to a tablet (Nagel, 2014).   Clearly the technology has made its way into students' hands, but what do we know about the effect of ubiquitous technology on student achievement?

One-to-one technology initiatives designed to meet the needs of todays' high-tech learners are expensive and time-consuming, yet not enough is known about their effects on achievement. A survey of research concerning one-to-one laptop programs initiated from 2001 to 2006 conducted by the Abell Foundation (2008) reported that such programs do appear to increase student engagement in learning, increase equity of access to technology, and promote the acquisition of twenty-first century skills, yet evidence for their impact on student scores on achievement tests is mixed and inconclusive.

A more recent survey of the available evidence showed similar findings. One-to-one programs lead to more engaged learners, increased technology skills, and help close the tech skills gap between low income and wealthy students (Goodwin, 2011). As with the Abell (2008) study, however, the impact on state achievement test scores was less clear and mixed results were reported. Goodwin (2011) ultimately concluded that without uniform integration of 1:1 laptop technology into every class, time for teacher learning and collaboration on ways to integrate technology into student learning, and the daily use of technology by students for purposes of collaboration and cooperative learning, meaningful impacts on student achievement were not likely to be found.

One very important reality facing districts who are implementing or considering implementing one-to-one initiatives is professional development for teachers. It is clear that adequate professional development is essential to an effective educational technology initiative and a lack of adequate development can be a major barrier to successful implementation of laptop programs (Ball, 2010; Beeson, Journell, & Ayers, 2014). However, more information is needed about the actual and perceived barriers teachers face in using educational technology in the classroom, and how professional development or support programs might better target some of those needs to facilitate opportunities for teachers to use technology as part of their pedagogy. A closer examination of teachers' levels of technology usage compared with their perceptions of the barriers and opportunities to the effective use of technology could help guide the development of professional development curriculums based on the needs of teachers at varying levels of classroom technology integration.

Actual usage of technology varies dramatically from teacher to teacher and student to student within such programs (Goodwin, 2011), making holistic claims about the impact of one-to-one programs on achievement difficult to measure or validate. It is not clear whether this variable may be influencing the mixed achievement results that have been observed. Whether laptops are actually being used by teachers in their classrooms as part of the teaching and learning process and how they are actually being used by students both inside and outside of class for learning purposes could have a significant impact on whether achievement gains are being made or not being made. After all, laptops which are rarely or never used, or that are used in ways that are not conducive to student learning, are not likely to positively impact student achievement.

Understanding how one-to-one laptop programs impact students can help shape the policies of school districts who are implementing or are considering the implementation of a one-to-one program (Zheng et al., 2016). If achievement levels are related to types and frequency of student use, that information may have important ramifications for the implementation, maintenance, and development of one-to-one initiatives. Onthe other hand, if the use of technology does not significantly correlate with student achievement, then that finding may influence decisions at the policymaking level regarding the investment of resources into one-to-one initiatives or using limited resources in other areas. This study is significant both in terms of informing policies regarding the district and school-level implementation of one-to-one laptop programs, and in terms of understanding and potentially influencing individual teacher and student decisions regarding the types and frequencies of laptop usage which are most conducive to promoting student reading achievement.

Research Questions

My formal research questions were formulated as follows:

1. Is there a relationship between the frequency of reported laptop use by students and their reading achievement as measured by the MAP reading test?
2. Is there a relationship between the reported ways in which students used their laptops and their reading achievement as measured by the MAP reading test?
3. What resources and skills enabled teachers to incorporate the laptops into their classroom activities and instruction?
4. What barriers and obstacles discouraged or limited teachers' incorporation of the laptops into their classroom activities and instruction?

Purpose of the Study

The purpose of this study was to add to the body of knowledge regarding one-to-one laptop initiatives in secondary education, to inform implementation decisions of school and district leaders who are adopting a one-to-one program, and to guide parents, teachers, and students toward the most effective ways to use laptop computers for learning. This study sought to clarify three major gaps in the existing literature. First, to discover whether varying levels and types of use of the laptops was significantly correlated with the achievement of students as measured by a standardized reading test. Second, to understand how students used their laptops and whether the ways in which students used their laptops was significantly correlated with their reading achievement as measured by a standardized reading test. Finally, to shed light on the factors that influenced teachers to frequently incorporate or infrequently incorporate the laptops into their classroom instruction and to discover the perceived barriers and opportunities that influenced the incorporation of technology in their instructional practices.

Researcher's Perspective

I have been a high school classroom teacher for twelve years and in that time have witnessed tremendous changes in the availability and use of technology in the classroom. When I first began teaching I frequently used transparencies on overhead projectors, showed movies on VHS tape, had a cell phone that was not smart, and had not even considered the possible uses of laptops or any other devices in my classroom. At the time of this study, my overhead projector had long since been replaced by a document camera and a Smart Board, my school had eliminated support for DVD and VHS technology in favor of online streaming, the vast majority of my students and I had access to smart phones, and every one of my students and I had 24-hour access to a laptop which was issued to us by our school district.

At the time of this study I was teaching in a high school which was in the fifth year of a one-to-one laptop initiative and I had witnessed the implementation of that program first hand. As a doctoral student focused on studying educational technology I had made numerous anecdotal observations about the program and its strengths and weaknesses, which led to a desire to explore the issue more systematically. I had often wondered how frequently my students were using their laptops, both in other teachers' classes and outside of school for homework and other learning, and whether the use of laptops was having a measurable impact on the achievement of students. It was this curiosity which brought this project about.

Definitions

A one-to-one laptop initiative has been defined by William Penuel, Senior Researcher at SRI's Center for Technology in Learning, as an education initiative which provides each student with the use of a portable computer with productivity software and which enables students to access the Internet through the school's wireless networks, and which focuses on using the laptops to help complete academic tasks (Abell, 2008; Fleischer, 2012).

Achievement was measured by student scores on the standardized test Measures of Academic Progress (MAP) test. These computer adaptive assessments are developed and distributed by the Northwest Evaluation Association (NWEA) in order to assess students' reading, language usage, and mathematics ability. The tests were administrated to all students in the district during the first weeks of each school year and again at the end of the school year in order to measure student achievement growth and achievement.

The laptops issued to students were DELL computers installed with the most recent Windows operating system each year and which had the full Microsoft Office suite and other software applications as requested by individual teachers and departments. They had Internet access through a wireless network installed in the school. Outside of the school they were capable of running the full range of software and accessing the Internet when Wi-Fi or wired Internet connections were available.

Ubiquitous one-to-one laptop initiatives such as the one in this study enable students to take the laptops home with them, giving them access to the laptop technology 24 hours a day. Students were issued laptops during the first weeks of school and returned them after their last final at the end of the school year. In the interim students kept the laptops and were able to use them at home or at school. Some capabilities were limited by the Internet filter system and other controls which were intended to prevent the misuse of computers by students. The filters limited access to social networking sites, music services, and violent or pornographic material, but otherwise the computers were fully-functional laptops.

Delimitations

This study focused on the quantity and quality of usage of the district-provided laptop computers by students. It attempted to measure the types of computer use students engaged in for purposes of calculating the correlation statistics. However, it did not measure actual student usage or actual student behavior, because it relied upon student self-reports of their usage patterns. It did not attempt to evaluate student grades, or student achievement on assessments other than the MAP reading assessment. It did not attempt to measure student engagement in learning or the development of twenty-first century skills. The goal of the study was to determine whether there was a correlation between student reading achievement and the use of the district provided laptop technology. It did not attempt to establish any causal relationships between use and achievement or correlations between teacher actions or pedagogies and student achievement growth.

This study sought to evaluate teacher attitudes and perceptions which participants identified as relevant to their use or non-use of the laptops in their classrooms. It did not seek to measure the effect of any specific professional development programs or opportunities on the use of laptops in the classroom. Nor did it attempt to establish any causal relationships between teacher attitudes and the use of laptops, although it did explore the presence of those attitudes and perceptions in a qualitative way. It did not attempt to correlate individual teacher's level of classroom implementation with student achievement.

This study attempted to evaluate how students used the laptops in order to estimate the quantity of classroom usage within each subject area, and the quantity and types of usage students reported outside of the classroom. This quantitative data was then correlated with individual student achievement on the MAP reading test. It did not attempt to establish any causal relationships between student types and frequencies of usage with student achievement, but measured the level of correlation between them. Regression models were used to predict achievement scores based on types and frequencies of student usage, showing which types of usage were predictive of reading achievement. Although this provided information regarding the types of laptop usage which could be used to predict a statistically significant portion of student reading achievement, those findings should not be construed as proof of causation.

Limitations

This study was limited by several factors. The first was the use of student surveys to evaluate laptop usage for the qualitative analysis of laptop usage. This was a subjective measure and may not reflect the actual usage of computers by students due to misrepresentation, either intentional or unintentional. It was also limited by the number of participants, including only those students who responded to the survey.

There are also inherent limitations in the use of reading tests, such as the MAP test, to measure a construct such as reading achievement. These include variability of test scores caused by student levels of fatigue, hunger, attentiveness, effort, and many other factors that were beyond the researchers' ability to control.

Teachers' self-reported levels of computer usage in the classroom and the perceived barriers and opportunities they reported were qualitative and therefore not generalizable.

Lastly, because of the lack of random selection of participants and the lack of any control group, the quantitative findings are correlative and should not be construed as evidence of causation.

Assumptions

It was assumed that student surveys accurately reflected the actual usage of the laptop computers through the course of the year in which the study was conducted and that the interviews accurately reflected teachers' attitudes regarding their use. Although small variations may have resulted from student and teachers' subjective perceptions and/or misrepresentations, in general the reports of students and teachers were assumed to provide a reasonably accurate indicator of actual use. It was also assumed that due to the anonymous nature of the surveys that there were no ulterior motives for individual students to misrepresent their use of the laptops, and that protecting the identity of individual teachers empowered them to express their feelings openly and without undue reservations.

Another assumption inherent in this study's research design was that the standardized MAP tests were an appropriate measure of student achievement. The researcher is aware that not all individuals will necessarily consider standardized tests to be a valuable measure of student learning. However, at the time of the study these tests were the primary method the school used to obtain data regarding student reading growth and achievement and the results of these tests were also being used in teacher effectiveness evaluations conducted by the district and school administrators. The results of the MAP tests were therefore assumed to be of value for the purposes of this study. The use of MAP data does not constitute an endorsement by the researcher of the MAP testing program itself or the use of standardized tests in our public schools as a policy or practice for the evaluation of individual students, teachers or schools. The results of these tests are subject to the limitations and constraints common to all such assessments and should be evaluated as such. For more information about the validity and reliability of the MAP reading test, the reader should consult the validity and reliability section of the methodology chapter of this dissertation.

CHAPTER TWO: REVIEW OF LITERATURE

The influence of technology on almost all aspects of contemporary life is profound, and the field of education is no exception. In fact, the notion of using machines to provide individually paced learning and instant feedback in order to improve education was widely explored at a time when a single electronic computer still filled an entire room (Casas, 2002). Although the Skinnerian learning machines of the 1960s never caught on in mainstream education, the idea of using machines to improve learning has persisted and now, when a powerful computer can fit in the palm of your hand, the idea that technology can be harnessed to improve learning seems more plausible than ever. However there is reason to be cautious and it is wise to attempt to understand the implications of change before embracing any innovation. As Fleischer (2012) argues, researchers need to be cognizant of the larger impact of technology on education and be conscious of the possibility that some of the qualities of good education could be lost in the rush to adopt technology.

Since the first large-scale one-to-one laptop program was launched in Maine in 2002 (Anderson, 2007) the use of technology by students has grown to the point that it is nearly ubiquitous. A wide-ranging study of one-to-one computer programs conducted by the Abell Foundation (2008) found that administrators and educators had four main goals in mind when adopting such programs in their schools: (1) increasing academic achievement, (2) increasing student engagement, (3) minimizing the digital divide, and (4) increasing the economic competitiveness of students by imparting twenty-first-century skills. The goal of this review of literature is to evaluate the available research regarding the impact of one-to-one computer programs on student learning in order to evaluate how effective such programs have been at achieving these goals.

Twenty-first Century Skills

Today's students are sometimes referred to as "digital natives" (Jett, 2013), a designation which reflects the fact that a large share of them have grown up in a post-Internet world and lead what can be described as digital lives (Fleischer, 2012). For this reason, many of them come to school with a familiarity with technology that allows them to quickly adopt and adapt to new educational technology practices (Niles, 2006). Educators cannot automatically assume, however, that every student is a digital native, just because of his or her age, and even those who are generally proficient with the use of computers for personal and social purposes may not necessarily be proficient with the academic applications of computer technology (Storz & Hoffman, 2013). This means that even when working with this generation of students, there is still a responsibility on the part of educators to help students develop the twenty-first century skills that they will need in the workforce (Friedman, 2007; Greenwood, 2007). Despite this need, there is reason to believe that education has fallen behind other sectors when it comes to the use of technology (Fleischer, 2012; Sauers, 2012).

The twenty-first century skills can be summarized as those skills which are the key ingredients of success in today's workplace, and the workplaces of the future. They include skills such as creativity, innovation, problem solving, communication, collaboration, information literacy, and digital citizenship (Chandrasekhar, 2009). It has been argued that the integration of technology in schools can be justified purely in terms of its impact on students' twenty-first century skills, and that the impact on achievement scores should not be a major concern when considering the efficacy of such programs (Borja, 2006) because education should focus on learning experiences which mirror students' tech-infused lives, both now and into the future (Spires, Oliver, & Corn, 2012). Warschauer (2006) agrees that the most important justification for the implementation of a one-to-one initiative is that it prepares students for the unique intellectual demands of today's world. If this is the case then it seems clear that such initiatives are indeed worthwhile as the evidence that one-to-one laptop programs can improve students' twenty-first century skills is overwhelming. The Abell Foundation (2008) report which examined the largest initiatives in the country including those in Maine, Michigan, Texas, Pennsylvania, Virginia, and Maryland concluded that both students and teachers gained technology and workplace related skills through such initiatives. Individual studies which corroborate these findings are so numerous that it is difficult to catalog them all (Allan, Erickson, Brookhouse & Johnson, 2010; Danielson, 2009; Greenwood, 2007; Harris, 2010; Hoyer, 2011; Jett, 2013; Lowther, Inan, Ross, & Strahl, 2012; Pogany, 2009; Rousseau, 2007; Sauers, 2012; Topper & Lancaster, 2013; Warschauer, 2007). Even Goodwin (2011), who argues that laptops have not been shown to increase achievement, agrees that the evidence clearly indicates that they do improve students' technology skills. In addition, Niles (2006) provides evidence that technology-rich classrooms equate to advantages and opportunities in post-secondary work world.

With computers infiltrating nearly every aspect of contemporary life, the development of computer skills as a result of one-to-one initiatives has been a concern for many researchers. Greenwood (2007) found that students in one such initiative reported significant increases in their computer skills. Similarly, Pogany (2009) found that teachers believed their own skills and their students' skills increased during a one-to-one laptop initiative. As seen above with the development of twenty-first century skills, there seems to be overwhelming evidence that one-to-one initiatives help improve both teachers' and students' comfort with using computer technology (Lowther, Ross & Morrison, 2003; Mo, Swinnen, Zhang, Yi, Qu, Boswell, & Rozelle, 2013; Rousseau, 2007; Sauers, 2012).

One key twenty-first century skill is collaboration. It appears that one-to-one initiatives can have a positive impact in helping students find opportunities for collaborative learning (Fleischer, 2012; Hoyer, 2011; Light et al., 2012b). One study provided evidence from teachers which indicated that students did indeed take advantage of technology in order to facilitate peer collaboration (Whiteside, 2013), and another provided compelling evidence that technology can facilitate more collaborative classroom practices (Gillard, 2011). In another instance a teacher who was dissatisfied with teacher-centered pedagogies found that laptops served as a catalyst enabling her to promote more collaborative student learning (Windschitl & Sahl, 2002). Niles (2006) points out that the kind of collaborative learning and teamwork which one-to-one laptop programs can facilitate will ultimately help students to be more successful in the workplace, and Goodwin (2011) adds that leveraging technology to promote student collaboration and cooperative learning is one of the key factors which affect achievement.

Another key skill for twenty-first century learners is communication. One informative study of student and parent impressions of a one-to-one laptop initiative found that both groups described increased communication as one of its most important impacts (Grant, Ross, Wang, & Potter, 2005). Similarly, Greenwood (2007) found that both teachers and students identified improved communication as the third most positive effect of their laptop program. Exposure to laptops can expose students and teachers directly to the kinds of communication media that are key to contemporary workplace communication and one important student learning outcome of one-to-one laptop programs is an increase in the quality of such communication (Harris, 2010).

Another study found that increased communication after school hours between teachers and students improved the quality of student work and decreased the turn-around time for students' submission of make-up work, causing researchers to conclude that communication and one-to-one laptop initiatives are mutually beneficial (Maninger & Holden, 2009). It seems clear that technology can enhance communication between teachers and students (Niles, 2006), and that such opportunities can ultimately enhance student communication skills, providing yet another key benefit to one-to-one laptop integration (Pogany, 2009).

One final twenty-first century skill identified by both Jett (2013) and Lowther et al. (2012) is critical thinking. Laptops appear to have a positive impact on critical thinking skills and higher order learning (Chandrasekhar, 2009; Grant et al., 2005). Virtual learning opportunities which require higher order thinking can help develop such skills (Klieger, Ben-Hur, & Bar-Yossef, 2010), and Internet access can promote a deeper understanding (Pogany, 2009; Warschauer, 2006; Warschauer, 2007). However, there are some concerns about equity which are raised by Rousseau (2007) who found that while high-ses students in one-to-one initiatives were engaged in critical thinking, their peers at low-ses schools were not. A deeper discussion of the issue of equity is thus warranted and will be developed more thoroughly below.

Student-Centered Learning

One very important potential benefit of a one-to-one laptop initiative is the promotion of student-centered classrooms. Niles (2006) argues that in such classrooms self-directed learning is affirmed and the teacher assumes the role of facilitator, guiding student learning rather than dictating it. Such an approach creates independent learners with more autonomous control over their own learning processes (Hatakka, Andersson, & Gronlund, 2013). Donovan, Hartley, and Strudler (2007) argue that a shift toward student-centered practices is required if a one-to-one program is to be effective and the Alberta Education (2010) report agrees that student-centered approaches are essential for the successful implementation of technology in schools. Similarly, Ball (2010) argued that teachers must become more student centered when working in one-to-one laptop programs. Clearly there is widespread agreement in the literature that such approaches are desirable and there are numerous studies which indicate that laptop programs can be effective facilitators of student-centered teaching and learning (e. g. Burgad, 2008; Casas, 2002; Lowther et al., 2012; Lowther et al., 2003; Rosen & Beck-Hill, 2012; Zheng et al., 2016).

During the statewide one-to-one laptop initiative in Maine in 2002 88% of teachers reported that student-centered teaching practices increased, during a district-wide program in Virginia in 2001 researchers reported that self-directed learning had increased significantly, and during yet another initiative in Pennsylvania in 2006 teachers reported that students were spending significantly more time in collaboration and projects (Abell Foundation, 2008). A similar study found that teachers in almost 90% of laptop classrooms were acting as a coach or facilitator of active student learning (Grant et al., 2005). When students are empowered by twenty-four-hour access to technology they can become independent agents directing their own learning through dynamic education processes which can enhance relevancy and the retention of information (Harris, 2010) and give them increased autonomy in controlling the pace and progress of their own learning (Light et al., 2012a). At the same time teachers can increase their pedagogical skills and develop practices which enable them to be facilitators of student learning (Allan et al., 2010) and can shift their role from the center of the classroom to guiding and channeling student-centered learning environments (Klieger et al., 2010). These personalized learning environments can change the teacher/student relationship, empowering students and enabling teachers to give up control (Light et al., 2012b), taking the focus off the teacher and putting it on the student and creating a more student-centric learning environment (Plummer, 2012).

Individualized Learning

One-to-one laptop initiatives can facilitate differentiated or individualized instruction and help teachers meet the diverse learning needs of their students (Danielson, 2009; Hoyer, 2011; Whiteside, 2013). Pedagogical differentiation facilitated by the use of technology can facilitate meaningful learning experiences which relate to students' own experience and promote genuine problem-solving skills (Freiman et al., 2010). Such shifts in instructional practices can allow for differentiated learning and promote higher-order thinking (Chandrasekhar, 2009) and give students opportunities for just-in-time learning and independent empirical investigation which can promote individualized learning (Warschauer, 2007).

The Digital Divide

The growing gap in twenty-first century skills between high and low-SES children serves to increase social inequities and make it more and more difficult for low-SES children to improve their social and economic status (Rousseau, 2007). Storz & Hoffman (2013) argue that the technological changes in the workforce have served to increase the stratification of wealth in the United States by giving a built-in advantage to wealthy children who have access to computer technology at home. Thus, Bird (2009) argues that the ideal scenario is one in which all children become digital native learners, and the only way to accomplish that ideal is to bring technology into our classrooms.

If one-to-one programs allow family finances to dictate laptop access through fees or charges, research shows that they will only serve to perpetuate the achievement gap (Jett, 2013). When access to computers is ubiquitous and universal, however, research shows that concrete improvements can be achieved including increased technology skills, broadened worldviews, and improved career advancement (Harris, 2010). Even in wealthy countries such as Sweden, where Internet access is nearly universal, one-to-one programs have been shown to equalize access to technology for underprivileged families who only have one computer in the home by giving students the opportunity to do schoolwork even when the home computer is being used by another family member (Hatakka et al., 2013). The impact in low-SES schools in Mexico was also profound in that it gave students access to educational technology when they would otherwise lack access entirely (Cervantes, Warschauer, Nardi, & Sambasivan, 2011). Findings like these have convinced many researchers that one-to-one programs can close the tech skills gap (Goodwin, 2011) and level the playing field between high and low-SES students (Hoyer, 2011), making them effective investments for schools which desire to reduce the digital divide (Harris, 2010).

Numerous studies point to the potential for one-to-one laptop initiatives to close the digital divide (e. g. Bryan, 2011; Harris, 2010). One such study showed that while socioeconomic status was predictive of student English language arts test scores at non-laptop schools, they did not predict scores at laptop schools (Kay, 2010). Another showed that in developing countries such programs can help bridge the digital divide and improve the computer skills of students (Light et al., 2012a). Yet another showed that the One Laptop Per Child Program in China resulted in dramatically improved computer skills, particularly among those who began the program with low or non-existent computer skills, causing researchers to conclude that such programs may be effective at reducing the digital divide (Mo et al., 2013). In the United States Bird (2009) found compelling evidence that students who lacked computer access at home benefited so dramatically that their posttest technology skills scores were not statistically different from those who did have access to computers at home after participating in a one-to-one laptop program. Taken together, these studies provide compelling research to support the claim that laptops programs are effective at reducing the digital divide, prompting the Abell Foundation (2008) to conclude that one-to-one initiatives have successfully increased the equity of access to technology.

Numerous equity issues are identified in the literature which laptops may positively influence. Harris (2010) argues that providing laptops for every child encouraged equity by providing opportunities for all students regardless of socioeconomic status. Pogany (2009) agreed that one of the most significant benefits of such a program is the encouragement of education equity. Although Weers (2012) also found that one-to-one programs promote equal access to information, he raised the important concern that even with laptops, not all families have Internet access in the home, an issue that will be addressed in more detail below. Finally, Zheng, Warshcauer, and Farkas (2013) found evidence that laptop programs can improve equity for at-risk learners, a demographic which might otherwise fall behind.

Simply introducing laptop computers into a school or school district is not a guarantee that the digital divide will automatically or immediately decrease, however. While the evidence cited above of the utility of laptop programs in decreasing the gap are compelling, there are numerous problems identified in the literature which districts and schools must be cognizant of. Jones (2013) points out that teachers' attitudes are an important factor which must be considered – teachers in that qualitative study expressed concerns about colleagues' failure to incorporate technology, which could negatively impact their students' proficiency gains. Furthermore, even teachers who do use the technology may not be using it in the most effective ways, limiting its potential to close the digital divide. McKeeman (2008) points out that although the gap in access to technology was closed during a one-to-one program, there were still significant gaps in the ways that students were using the laptops, revealing that while advanced students were using the laptops as educational instruments, other students were using the laptops merely as tools, failing to access deeper technology skills. Storz and Hoffman (2013) found that teachers in high-income communities were more likely to harness computer technology to promote critical inquiry than those in lower-income areas. This kind of gap in the way laptops are utilized and a gap in the development of skills resulting from such use could enable the digital divide to persist even when laptops were ubiquitously distributed (McKeeman, 2008).

Other digital equity issues that arise have to do with students' ability to use the laptops effectively outside of school. If students lack Internet access at home, they may not be able to use the laptops to communicate with classmates or the teacher, and may not be able to access class materials which can unintentionally marginalize those students (Pack, 2013). One study showed that students living in communities without broadband Internet access displayed significant differences in their personal and classroom use of laptops during a one-to-one laptop program (Lloyd, 2012). Students with computer access at home begin with higher levels of computer fluency to begin with and may benefit from a laptop program more readily than their peers (Warschauer, 2006). There are clear benefits in being able to use laptops for long-term outside of class projects and research (Boardman, 2012) and to explore resources and new ideas (Jones, 2013), and there is some evidence that using the laptop at home is one of the best indicators of student achievement (Jett, 2013; Shapley et al., 2010), which means that students who lack home access to the Internet may not benefit fully from a one-to-one program, which may be a significant barrier to closing the digital divide.

Classroom Discipline

Numerous studies of one-to-one laptop programs have shown that such programs can have a positive impact on student classroom behavior (Gillard, 2011; Goodwin, 2011; Plummer, 2012). For example, one study of four elementary schools in Texas showed that student discipline issues in a one-to-one cohort dropped significantly while issues among students in a control group did not change (Rosen & Beck-Hill, 2012). However, the issue may be more complicated than immediately meets the eye. Storz and Hoffman (2013) found that while classrooms were quieter and experienced fewer disturbances, there was more off-task behavior than in traditional classroom settings, and that type of behavior was difficult for teachers to monitor. For this reason, Jett (2013) argues that monitoring software, or very vigilant teachers, are necessary to keep students engaged with the curriculum rather than outside distractions. Teachers in one qualitative study expressed a strong desire to be able to monitor and control student laptop computers during class (Klieger et al., 2010), and numerous such software applications are available. Monitoring software is not a panacea, however, as some teachers have reported that their use is cumbersome and requires teachers to constantly monitor their computer screens for off-task behavior or cheating (Ball, 2010) and qualitative evidence of students spending time on non-academic websites due to inadequate monitoring by the teacher can be found (Beeson, Journell, & Ayers, 2014). It seems clear that appropriate monitoring and consequences for inappropriate use are important in keeping students focused on academics, particularly for those students who have difficulty self-regulating their resistance to tempting distractions (Carraher, 2014). High performing students may be able to stay motivated and resist such diversions, but the lure of social media and games may prove to be too much for other students who seek short term entertainment over long-term learning benefits (Hatakka et al., 2013). In one study in particular, the most significant concern teachers reported was that without effective classroom management the laptops were a distraction for students (Pogany, 2009). In another qualitative study disruptive uses such as playing games and accessing social media were cited as one of the significant challenges in bringing laptops into the classroom (Lindqvist, 2015). These are all indications of the perspective described by Nielson, Miller and Hoban (2015) that connected devices are viewed by many students as tools for social networking, not tools for learning.

Like any significant change in any field, new education initiatives create new challenges for educators. In the Henrico County laptop initiative in Virginia in 2001, teachers reported that the laptops increased the need for planning time and increased classroom management issues (Abell Foundation, 2008). Teachers in another such program, this one in rural North Dakota, reported frustration with students playing games, browsing the Internet, or listening to music during class (Burgad, 2008). Yet another case study in California found that without appropriate enforcement of the districts' acceptable use policy, the laptops became a distraction, not a benefit to students' learning (Chandrasekhar, 2009). Perhaps more interestingly, students themselves have reported an awareness of the distractive potential of laptops in the classroom. Both students and teachers involved in a one-to-one program at an all-girls school in Virginia reported that a major pitfall of the program was the distractibility of students (Greenwood, 2007), and another study in North Carolina reported frustration among both students and teachers at the numerous distractions created by laptops (Jett, 2013). Indeed, ubiquitous technology appears to bring with it a whole new set of challenges for both students and teachers in maintaining student attention and discipline (Niles, 2006).

The problem of student distraction and discipline may manifest very differently in different schools, and with different teacher approaches and interpretations. For example, one study conducted in Maine found that a low-SES school with significant disciplinary problems found that the introduction of one-to-one technology increased those problems, while a high-SES school which was highly focused on academics found that the laptops enhanced the schools' academic goals (Roussea, 2007). Another study noted a big difference between teacher and student perceptions of what constituted distraction and what was acceptable use of technology, creating difficulty in finding the appropriate balance between freedom and control. Teachers viewed certain behaviors such as instant messaging as distracting from learning, while students viewed those same behaviors as commonplace and did not equate them with disengagement (Niles, 2006). Some teachers in a program in New South Wales responded to such challenges by resisting or even refusing to use the laptops, effectively blocking access for entire classrooms of students and creating a significant barrier to implementation, while other teachers identified and implemented strategies to change student behaviors and overcome those challenges (Zuber & Anderson, 2013). A qualitative study of teacher attitudes revealed similar patterns – one teacher found solutions for developing collaborative constructivist learning strategies through laptop use while another teacher's belief that student liberties such as collaborative and/or constructivist projects were a threat to classroom order appeared to prevent her from finding ways to incorporate the laptops into her classroom instruction (Windschitl & Sahl, 2002).

Student Engagement

Increasing student engagement is one of the four main goals of laptop initiatives identified in the Abell Foundation (2008) study of laptop initiatives. Engaged students stay on task for longer periods, enjoy learning more, are more likely to effectively work independently and in general pursue more learning opportunities both at school and at home than disengaged students (Warschauer, 2006). The Abell Foundation (2008) review documented evidence of increased student engagement due to one-to-one laptop initiatives in Maine's 2002 initiative, in Michigan's 2002 initiative, in Virginia in 2001, Maryland in 2005, and Pennsylvania in 2006. Based on all of this evidence together the reviewers concluded that laptops do appear to increase student engagement, and there are many more recent studies which further support this claim (Chandrasekhar, 2009; Goodwin, 2011; Larkin & Finger, 2011; Maninger & Holden, 2009; Milton & Canadian Education Association, 2008; Plummer, 2012; Pogany, 2009; Zheng et al., 2016).

In one such study 79.8% of students reported that laptops made schoolwork more interesting, 87.5% of teachers reported that students were more interested in learning when using laptops, and 84.2% of parents agreed that laptops made schoolwork more interesting for their child (Burgad, 2008). Laptops can help to involve students in more engaging real-world learning environments (Danielson, 2009) and can create greater interest in content and motivate students to work harder and learn more (Greenwood, 2007). Computers have also been shown to benefit student engagement in writing tasks, providing a more efficient and engaging means of research (Storz & Hoffman, 2013), increasing student motivation when writing, and allowing them to produce written work of greater length and increased quality (Freiman, Beauchamp, Blain, Lirette-Pitre, & Fournier, 2010; Suhr, Hernandez, Grimes, & Warschauer, 2010). When used effectively laptops can make schoolwork more interesting for students (Zheng, Warschauer, & Farkas, 2013), and this excitement can lead to self-reinforcing cycles in which increased student engagement in turn motivates teachers to find new and innovative ways to further incorporate the laptops into their lessons (Jones, 2013). In short, laptops can be more fun than traditional learning (Hatakka et al., 2013; Niles, 2006) and can make students more interested in learning (Lowther et al., 2012; Lowther et al., 2003). All of this increased engagement may pay real dividends in terms of student achievement as well, as at least one researcher has argued that an increase in the number of students passing the Texas Assessment of Knowledge and Skills (TAKS) could be attributed to the increased student engagement resulting from a one-to-one laptop program (Hoyer, 2011).

One additional positive benefit of student engagement could be improved attendance, as students could be more likely to attend classes in which they are more engaged. Indeed, researchers have found a connection between laptop programs and student attendance (Gillard, 2011). In addition, Chandrasakhard (2009) reports that a participating school district attributed an increase in attendance and student engagement to a one-to-one laptop program. Another study showed that laptop students' unexcused absences decreased 29.2% at the same time that a control groups' increased by 56.6% (Rosen & Beck-Hill, 2012), and yet another district reported that the student dropout rate fell 54% after the successful implementation of a laptop initiative (Plummer, 2012). Many of today's students are familiar and comfortable with technology, and there is compelling evidence to support the claim that in order to adequately engage today's students educators must adapt to this new reality (Whiteside, 2013).

Student Organization

Organization skills are essential for students, and those transferable skills are highly desired by both colleges and employers (Silvernail & University of Southern Maine, 2005). When used effectively, there is strong evidence that laptops can support the development of organization skills among students (Carraher, 2014; Hoyer, 2011). For example, in one study 79.8% of students reported that laptops improved their organization. While it is true that only

50% of those same students' teachers reported an improvement in student organization skills, the researcher argues that this discrepancy was the result of the failure on the part of those teachers to utilize the classroom organization strategies provided in professional development, an opportunity which their colleagues took advantage of (Burgad, 2008). This finding provides evidence that the benefits of laptops are often dependent upon individual teachers' ability to take full advantage of the potentialities they offer. In one study 60% of parents reported that laptops improved their child's organization skills (Silvernail & University of Southern Maine, 2005), and in another more than 60% of students themselves agreed that laptops had helped them become more organized (Zheng et al., 2013). One important benefit of improved organization skills is the accessibility to learning opportunities for students with learning disabilities and/or emotional, behavioral, or attention challenges. For these students the ability to keep work organized and accessible has been shown to provide a greater opportunity to engage with the general education curriculum (Kusiak, 2011).

Standardized Testing

There is much debate regarding the efficacy and utility of standardized testing in today's education system. Although this debate is outside the realm of the present review, it is important to note areas in which the standardized testing debate interrelates with issues specific to one-to-one laptop programs in particular. Some researchers have argued that standardized tests do not measure the twenty-first century skills that laptops influence (Goodwin, 2011; Silvernail & University of Southern Maine, 2005), and that much of what is learned on laptops is not covered by standardized tests (Suhr et al., 2013). This mismatch has led some researchers to examine the overall quality of education when assessing the effectiveness of laptop initiatives, rather than focusing on narrowly defined achievement scores (Maninger & Holden, 2009). For example, Freiman et al. (2010) noted the limitations of reliance on standardized test scores and instead opted for an expanded model of learning as an open ended process which included student attitudes and emotions.

One major concern expressed by researchers is that while laptops promote learning via computer, many standardized tests are still administered on paper, potentially disadvantaging laptop learners (Zheng et al., 2013), leading to calls for better measures of achievement than pencil and paper tests in evaluating laptop initiatives (Milton & Canadian Education Association, 2008). In fact one study actually showed a slight and non-significant drop in student writing scores after the implementation of a one-to-one initiative, which the researchers attributed to the paper and pencil format of the tests (Goodwin, 2011). Warschauer (2006) adds that the specific advantages which laptops bring, such as ease of research, multi-media modalities, and the simplified revision process may not show up in paper and pencil test scores. And even beyond the format of such tests, the very conditions of standardized tests, which are often based on a short essay written in a single setting, do not match well with the type of writing done on laptops, which often includes research, drafting, feedback, revision, and publishing over an extended period of time (Zheng et al., 2013). Zheng et al. (2013) go on to cite a study which showed a positive correlation between the use of computers and test scores on a computer-based standardized test, lending additional credibility to the claim that paper and pencil tests may not be adequately evaluating the impact of computer initiatives.

A more fundamental mismatch between standardized tests and computer-based learning may be at work here as well, one which is limiting the potential of such tests to measure student growth and learning. Harris (2010) argues that standardized tests tend to measure knowledge, not creativity, and that since ubiquitous computing promotes creative learning, the gains students and teachers experience in one-to-one laptop environments may not show up in the form of standardized test scores, which may explain inconclusive effects on student achievement. Other researchers agree that constructivist learning, supported by technology, may not directly impact test scores, making the inconclusive results of such studies unsurprising (Lowther et al., 2003). Others point out that standardized tests, in their current form, don't adequately measure twenty-first century skills and therefore are not sufficient to measure the full range of benefits which one-to-one programs might deliver (Silvernail & University of Southern Maine, 2005; Ware & Warschauer, 2005).

It is possible that the benefits of one-to-one laptop programs are limited to promoting twenty-first century skills, and it may be that schools should see them as valuable in that regard, rather than expecting them to impact test scores (Borja, 2006). However, Harris (2010) points out that standardized testing is currently an important part of how students are assessed and argues that perhaps teachers should maintain balance between creative and traditional instruction in order to maximize the benefits of one-to-one laptop programs. It is also possible that authentic forms of assessment could be more effective at measuring the overall impact of a one-to-one program, however such forms of assessment are not yet standardized, and are not yet influential in education policy or administrative decisions, leaving traditional standardized tests as the most reliable and influential form of student assessment (Suhr et al., 2010).

Lack of Achievement Data

The current research on the impact of one-to-one programs and achievement is mixed and preliminary (Borja, 2006), and further research is needed (Storz & Hoffman, 2013). While it is true that there is a significant body of research relating to laptop initiatives in general, there is little quantitative research on the impact of such initiatives on test outcomes (Suhr et al., 2010) as much of the research to date has evaluated the impact on computer skills or computer competence rather than specific academic gains (Storz & Hoffman, 2013).

One of the most important reasons that sufficient data on the impact of one-to-one initiatives on student achievement have not been produced may be that such initiatives are relatively new. Since almost any technology initiative requires a few years for its full impact to be realized (Warschauer, 2006), many published studies of immature programs may not be able to provide conclusive evidence regarding the full impact of one-to-one initiatives. Indeed, there is some evidence to suggest that test scores can actually drop in the first year of a new laptop program and then rebound in later years (Zheng et al., 2013). This is a major limitation, since many studies focus on just one year of implementation (Borja, 2006). For example, a study by Alberta Education (2008) which focused on the first year of a one-to-one program found that it is difficult to assess the impact of such a program in such a short time frame; another study which showed no significant impact on student reading scores focused on only one half-year period (Bryan, 2011); another study examined teacher concerns during only the introduction of a one-to-one computing initiative (Donovan, Hartley, & Strudler, 2007); and yet another exploratory study found that after five months an initiative did not have a statistically significant impact on the achievement of any demographic sub-groups (Hansen, 2012). While such studies can potentially provide valuable information, they are not likely to yield conclusive results regarding the long-term effect of computers on student achievement. Storz and Hoffman (2013) conducted a phenomenological study of teacher and student perceptions of a laptop initiative and found that although both groups were thinking about the potential effects on learning it was too soon to assess the program's impact on achievement, and ultimately they called for further research into the long-term development of the one-to-one initiative in order to better evaluate its effectiveness.

There appears to be a significant learning curve for teachers which may account for the delay in results. For example, in Maryland's 2005 Talbot County initiative, students whose teachers had two years of experience using the laptops showed more academic improvement then other groups (Abell Foundation, 2008). In addition, one qualitative study concluded that the difference in the effective use of technology between two teachers may have been the result of experience – one highly effective teacher had been using the computers for three years while another, less effective teacher, was in his first year of teaching in a one-to-one environment (Beeson et al., 2014). There are numerous factors involved in the use or non-use of computers by individual teachers including but not limited to years of experience, and those issues will be explored in more detail later in this review.

Despite the aforementioned dearth of evidence regarding the impact of long-term one-to-one laptop initiatives on achievement, there is a small body of emerging evidence investigating longer-term initiatives which is quite compelling. For example, in studies of the Texas Technology Immersion Project, positive effects on achievement did not begin to emerge until the third year of the program (Abell Foundation, 2008), and another study provided some evidence that laptop use can positively impact literacy test scores if used over multiple years (Suhr et al., 2010). One particularly compelling study showed that after eight years of a one-to-one laptop program students living in poverty were learning at the same rate as students not in poverty, providing hope for educators interested in closing the achievement gap between high ses and low ses students (Weers, 2012). Although much of the existing literature focuses on newly implemented programs, the small body of research regarding the effectiveness of mature programs is very compelling and warrants further investigation.

Mixed Achievement Results

Although we are well into the second decade since one-to-one laptop programs first began to be implemented, the research on achievement is still very limited and there are numerous blind spots in the research (Fleischer, 2012). Although a survey of 364 leaders of large districts with one-to-one initiatives found that 78 percent believed that the laptops were having a moderate or significant effect on achievement (Gillard, 2011; Goodwin, 2011), empirical quantitative connections between laptops and achievement are difficult to find (Gillard, 2012). While some results are promising, often conflicting data appears within the same or similar studies.

In Texas, for example, students at one-to-one schools were found to be more likely to pass the Texas Assessment of Knowledge and Skills, but the same data set revealed that middle schools students in one-to-one programs were no more likely to pass the test than their peers (Hoyer, 2011). Another study, this one in China, found significant improvements in math test scores, but found no effect on Chinese language test scores (Mo et al., 2013). A study of math achievement in North Carolina produced mixed results as well, with some subgroups showing improvement but others showing no significant effect (Smith, 2012). Yet another study, this one in a small rural North Dakota high school, found that math scores increased significantly, while reading scores declined sharply, prompting the researchers to call for more specific investigations into the actual implementation of laptop programs to investigate such apparent contradictions (Burgad, 2008). Dunleavy and Heinecke (2008) agree that more study of the actual implementation of initiatives is needed in response to their own findings, which showed mixed results on middle school math and science tests in a one-to-one program. Individual teachers have widely varying beliefs and perceptions which influence their specific practices, and those individual practices are tied to student achievement (Whiteside, 2013). It is clear that teachers with the same access to technology often implement that technology very differently, which may explain the sporadic nature of gains in student achievement found throughout the research literature (Spires et al., 2012). Whatever the cause, it is clear based on the findings of two recent literature reviews that the existing evidence provides weak support for the claim that computers improve student achievement (Fleischer, 2012; Warschauer et al., 2014).

There are numerous studies of one-to-one laptop initiatives which show little or no impact on student achievement (e.g. Milton & Canadian Education Association, 2008). One particular quantitative study using an experimental and control group showed no significant gains in reading test scores (Bryan, 2011), and another which compared demographic groups performance before and after a one-to-one implementation based on numerous quantifiable student outcomes also found no significant improvement (Hansen, 2012). A study of students participating in the Freedom to Learn program in Michigan found that students with ubiquitous access to technology did perform at the same or higher level than control students in most instances, but the advantages were not found to be statistically significant (Lowther et al., 2012). Based on an investigation of data collected in Virginia, Maine, Michigan, and Texas, the Abell Foundation (2008) study concluded that there is not yet conclusive evidence that one-to-one laptop programs promote gains in student achievement. Taken together, this body of evidence reveals that much of the data regarding the impact of one-to-one laptop initiatives on student achievement are mixed and inconclusive.

Evidence of Achievement Benefits

Despite the mixed results reported above, there are numerous empirical studies using experimental or quasi-experimental designs which do show achievement benefits (e.g. Lowther et al., 2003; Mo et al., 2013; Rosen & Beck-Hill, 2012; Suhr et al., 2010; Yang, Zhang, Zeng, Pang, Lai, & Rozelle, 2013). One empirical study in particular showed that after two years of participation, laptop students outperformed a control group on changes in language, writing, and analysis test scores (Suhr et al., 2010). Another study of four high-school campuses showed that after the implementation of a laptop program two of the four showed growth in reading scores and all four showed growth in math, science, and social studies, and an average of the four campuses showed growth an increase in the number of students passing the standardized test (Hoyer, 2011). Yet another study, which grouped students by free or reduced lunch status, observed statistically significant increases in academic achievement in both groups and concluded that the program was an effective intervention (Weber, 2012). Finally, an empirical study of over 5,000 students showed a 21 percent increase in test scores for high school students and a 13% increase in test scores for third graders in the same district (Plummer, 2012). Although far from presenting a conclusive case, these studies, taken together, do form the beginning of a compelling argument for further research into the possible benefits of one-to-one laptop programs in increasing student achievement.

Frequency of Use and Achievement

While much of the evidence from the 2004 Texas Technology Immersion Project was inconclusive, one important finding was that students who used the laptops for learning, both in class and at home, had significantly higher standardized test scores in both reading and math. Similarly, results from the 2001 Henrico County initiative in Virginia showed that the students who were found to be using their laptops the most frequently had significantly higher scores on Virginia's standardized test in World History, Biology, Reading, and Chemistry. Based on the evidence from these two studies, the Abell Foundation (2008) concluded that higher use of laptops does indeed lead to higher academic gains. In addition, a study of 21 schools over the course of three years found that while levels of use by teachers was not a significant indicator of student achievement, levels of use by students was a consistently positive predictor of student reading achievement (Shapley et al., 2010). And some preliminary evidence indicates that such effects might be cumulative – that increased exposure to computers in general can increase student performance in specific one-to-one environments (Hansen, 2012).

Math achievement

Although results were inconclusive in other subject areas, studies of the 2004 Texas Technology Immersion Project did show a statistically significant effect on mathematics scores (Abell Foundation, 2008). A smaller study in rural North Dakota showed similar results—while outcomes were mixed in other subject areas, math test scores increased substantially in both of the tested subgroups (Burgad, 2008). One very compelling study conducted in China using random assignment to groups also showed statistically significant improvements in math test scores for one-to-one computer program participants (Mo et al., 2013), and a similar study, also conducted in China and also using random assignment to groups, found that math test scores increased significantly for one-to-one students and that the increase was the same for both boys and girls (Yang et al., 2013). Another quantitative study, this one in Texas, used demographic matching to identify two control schools and compared their results to those of two one-to-one schools, finding that both fourth and fifth grade experimental students outperformed their control counterparts in math scores on the Texas standardized test (Rosen & Beck-Hill, 2012). Finally, a meta-analysis of seven empirical studies of mathematics achievement which included 21 reported effect sizes, found that overall there was a statistically significant difference between students in one-to-one laptop programs and control groups in the area of mathematics achievement (Zheng et al., 2016). There is an emerging body of empirical evidence which indicates that one-to-one programs may have the potential to increase math achievement.

Writing achievement

While Fleischer (2012) claims that the evidence that computers improve writing skills is still weak, Gillard (2011) argues that writing is one of the areas in which the benefits of one-to-one programs are clearest. Suhr et al. (2010) cited numerous studies which show that laptop students tend to submit longer essays of higher quality to inform their own study which provided quantitative data using control and experimental groups which show statistically significant performance differences on standardized writing tests after just two years of implementation. Lowther et al. (2003) conducted a mixed methods study and found that one-to-one students significantly outperformed control students with effect sizes in six of the eight subgroups exceeding +0.80. Studies of the statewide Maine initiative in 2002 also found statistically significant increases in student writing scores, though scores in other subject areas were not significantly effected (Abell Foundation, 2008). A more recent meta-analysis of three empirical studies which included 11 reported effect sizes, found that overall there was a statistically significant difference in the writing achievement of students in one-to-one laptop programs compared to control groups, leading the authors to conclude that the use of laptops for drafting, revising, and sharing student writing can be particularly beneficial (Zheng et al., 2016).

This empirical data is corroborated by numerous studies which reveal a pervasive perception among researchers, students and teachers that computers promote positive impacts on student writing skills. One study surveyed more than 1,000 students and teachers, interviewed 200 teachers and conducted more than 750 hours of classroom observations and concluded that students in laptop schools write much more, revise more frequently, get more feedback, and take more pride in their writing than students in traditional classrooms (Warschauer, 2006). A qualitative study found through classroom observations and surveys of students and teachers that laptop students wrote more often and produced higher quality essays of greater length than they had before the program (Milton & Canadian Education Association, 2008). Students report that they believe writing is easier with laptops than using traditional methods (Carraher, 2014) and that their writing is quicker and better with laptops (Freiman et al., 2010). In fact, more than 70% of students in one survey agreed that they wrote more, revised and edited more, and that the quality of their writing improved after receiving laptops (Zheng et al., 2013). A national survey found that while only 17% of students said they enjoy school writing, 60% of students agreed that computers make them more likely to edit and revise their writing (Jett, 2013). These findings are corroborated by teachers who agree that students wrote more (Pogany, 2009), and that the quality of students' compositions improved after laptops were distributed (Freiman et al., 2010). Although the available data is far from conclusive, there is a compelling body of evidence which indicates that one-to-one laptop programs may benefit student writing.

Reading achievement

There is little empirical data to support the relationship between one-to-one laptop initiatives and reading achievement, and the evidence that is available is mixed, but promising. One mixed-methods study of 476 elementary school students in Texas, which used an experimental group compared to matched schools with similar demographic characteristics showed that reading achievement as measured by standardized assessment scores was consistently positive (Rosen & Beck-Hill, 2012). Another promising study showed that laptop computers mitigated the fourth-grade slump which often occurs in reading scores and lead to significantly higher performance among laptop students compared to their non-laptop peers (Suhr et al., 2010). In contrast, a meta-analysis of thirteen reported effect sizes within four empirical studies of reading achievement found that there was not a statistically significant difference between laptop participants and control groups, although there were significant differences in each of the other four academic areas they examined (Zheng et al., 2016). Definitive conclusions are impossible to draw from such limited evidence, but clearly this is an area which warrants further investigation.

Science Achievement

Evidence of an impact on science achievement is even more limited, with one study showing a significant effect of a laptop treatment on student science test scores (Dunleavy & Heinecke, 2008), and one other study which failed to show a significant effect on science achievement (Hansen, 2012). A Recent meta-analysis of empirical studies of one-to-one laptop studies showed a similar dearth of evidence, locating only two studies which fit their criterion for inclusion. Based on three reported effect sizes from those two studies Zheng et al. (2016) found a statistically significant difference between laptop participants and control groups in the area of science achievement. Drawing definitive conclusions about the effect of one-to-one laptop programs based on such a limited number of studies in the area of science achievement, however, seems unwarranted.

Achievement Gap

The technological changes in the 21st century workplace have exacerbated class stratification in the United States due to the gap in academic achievement and 21st century skills between high-SES children and low-SES children which has worsened economic and social inequality (Rousseau, 2007). While there is clear evidence cited above that one-to-one initiatives can help reduce the twenty-first century skills gap, the question of whether they can address the achievement gap is much more controversial. A meta-analysis of empirical studies of one-to-one laptop programs found that while some studies have shown achievement benefits for disadvantaged students, those benefits are not seen in all such programs, leading the authors to conclude that the issue of reducing inequality is more complex than simply providing laptops to disadvantaged students (Zheng et al., 2016). The conflicting and sometimes confusing evidence of the relationship between one-to-one programs and the achievement gap is explored further in the next two sections.

Achievement Gap Worse

There is some evidence that one-to-one initiatives may help high achievers more than low achievers, which could potentially increase rather than decrease the achievement gap. For example, math scores during the Technology Immersion Project in Texas revealed more benefits for high achieving students than low-achievers (Abell Foundation, 2008). Another study found severe inequities in the way that laptop programs were implemented, concluding that students in high-SES schools engaged in higher-level thinking activities while low-SES students engaged in more basic learning, which may have been a factor in the failure of the laptop program to reduce the achievement gap (Rousseau, 2007). A study focused on the achievement gap between black and white students found similar results – white students scores increased more quickly than those of black students after the implementation of a one-to-one initiative (Smith, 2012). A study which focused on the achievement gap between boys and girls in science classes showed that while both boys and girls were given the same hardware, boys used the technology in more sophisticated ways, building their science content mastery faster than girls, again failing to reduce the gap in achievement. Warschauer (2006) observes that already-privileged students will have an advantage in utilizing laptops, which means that one-to-one programs cannot be counted on to reduce education inequities in our schools. Eight years later Warschauer (2014) built on those findings and argued further that without adequate pedagogical support technology programs can actually be detrimental to students.

Achievement Gap Better

On the other hand, there is some compelling empirical evidence to indicate that one-to-one laptop programs can help close the achievement gap and promote educational equity (e.g. Harris, 2010). One study in particular found that students who did not have computer access at home showed rapid rates of advancement which eliminated the posttest achievement gap for digital divide learners (Bird, 2009). In relation to the gender achievement gap, one study showed that math achievement between males and females had narrowed after a laptop implementation, and although the effect size was small and a gap continued to exist, the researcher concluded that the digital conversion had reduced the gender achievement gap (Smith, 2012). Another study examined a number of different learning settings and found that girls learned as well as boys in computer assisted learning environments (Yang et al., 2013). In relation to the Socio-economic achievement gap, one study concluded that the achievement gap between free and reduced lunch students and their non-eligible peers had been mitigated through student participation in a one-to-one laptop computer program (Weber, 2012), and another concluded that despite evidence that students in poverty generally tend to lose ground over time, free and reduced lunch students in a one-to-one laptop program learned at the same rate as other students, and there was no statistically significant achievement gap between the two groups after a computer initiative had been implemented (Weers, 2012). One final study evaluated at-risk learners in schools in both California and Colorado and found that at-risk learners used their laptops as much or more than their counterparts and used them in ways that addressed their unique needs, leading to strong achievement gains and supporting the researchers' conclusion that laptop programs can improve educational equity for at-risk learners (Zheng et al., 2013).

Twenty-Four Hour Access

Students' unequal access to technology at home is a significant challenge (Warschauer, 2007), and an area that all educators must consider when implementing twenty-first century learning programs such as a one-to-one laptop initiative (Weers, 2012). Teachers tend to prefer that students be given 24-hour access rather than keeping their computers at the school (Jones, 2013; Milton & Canadian Education Association, 2008), and Anderson (2007) recommends that superintendents find ways to insure all students have access to the Internet at home if they hope to overcome barriers to educational equity. If students are restricted to day-user status while their peers have access to computer technology at home there is a significant potential for the perpetuation of the achievement gap (Jett, 2013). Students without access to Internet connectivity at home have been shown to display significantly different patterns of use than connected students (Lloyd, 2012) and when some students are denied the opportunity to complete work at home, they will by necessity have to complete their work in school (Chandrasekhar, 2009), potentially taking away from valuable instructional time. Although innovative solutions such as mobile laptop carts for classroom use can solve the problem of computer access at school with considerably less investment of capital than a one-to-one initiative (Grant et al., 2005), such programs may not meet the needs of students who lack computer access at home.

Issues in Implementation

It is clear that the impact of one-to-one laptop initiatives on student achievement so far has been mixed and that conclusive evidence is lacking. One significant reason for this may be differences in how such programs are implemented. Simply providing students with laptops does not automatically integrate technology into the classroom unless teachers change their instructional practices (Burgad, 2008; Ball, 2010; Windschitl & Sahl, 2002). In addition, the mere presence of the technology itself will not impact student learning or achievement, the key lies in how the technology is used (Bryan, 2011; Goodwin, 2011; Harris, 2010; Hoyer, 2011; Silvernail & University of Southern Maine, 2005; Ware & Warschauer, 2005). If teachers do not change their methodology to incorporate the laptops into their instruction then the laptop program will have a minimal effect on student achievement (Anderson, 2007). However, technology can have positive impacts depending on how it is implemented (Rousseau, 2007).

Implementation Gap

Numerous researchers have observed significant differences in the way that one-to-one laptop initiatives are implemented, and those differences may be important factors in determining whether or not such programs ultimately benefit all learners equally and promote educational equity. Warschauer (2006) has argued that while laptops can enhance education quality in schools that are already good, often they don't turn bad schools into good ones. Kusiak (2011) observed in a qualitative study that students in an affluent school engaged in a rich curriculum and were empowered to reach high levels of thinking and learning while students at a working class school received a relatively limited curriculum which produced less advanced learning experiences. Rousseau (2007) similarly observed that while high-SES students often began with basic computer skills and were able to engage in innovative and complex learning activities, students in low-SES skills the focus was on developing basic computer literacy, detracting from academic goals. Cervantes et al. (2011) found that a high-SES school was consistently able to integrate laptops into instruction, while doing so at low-SES schools required much more effort and depended upon the organizational capacity of those schools. Warschauer (2007) similarly concluded that teachers in high-income schools were more likely to promote critical inquiry than teachers in low-income schools. Rousseau (2007) observed that in a low-SES school in Maine a high level of disciplinary problems seemed to be exacerbated by the introduction of technology, while at a high-SES school the laptops served to enhance the existing academic focus. These differences in implementation show that laptops must be used thoughtfully and purposely if they are to be expected to help achieve educational equity (Kusiak, 2011).

Differences in Teacher Implementation

Effective teaching does not depend on technology, and ineffective teaching is not solved by it either. When teachers simply add technology to poor teaching practices, it will not make a difference in student learning (Pack, 2013). For example, one qualitative study of three individual teachers in a one-to-one laptop school showed that while technology was used as a catalyst for movement toward a constructivist pedagogy by one participant, two other participants did not find innovative or effective ways to incorporate the technology into their instruction (Windschitl & Sahl, 2002). In another qualitative study, a teacher who was confident in his ability to use technology for personal and professional purposes found that he struggled to find ways to connect that know-how to content and pedagogy in order to provide effective learning opportunities for his students (Beeson et al., 2014). Yet another qualitative multiple case study concluded that one-to-one access to computers alone is not sufficient to produce droves of student authors capable of brilliant writing (Jett, 2013). If teachers cannot find ways to successfully integrate technology into their instruction, the laptops run the risk of simply being abandoned in a closet (Light et al., 2012a). Teachers with similar access to resources will integrate technology in very different ways (Spires et al., 2012) and some teachers will transition to computer-based teaching more easily than others (Storz & Hoffman, 2013). Ultimately it is the individual teacher who will determine the success of technology integration in the classroom, and therefore the impact of such a program on student achievement (Jones, 2013). Indeed, Goodwin (2011) found that one of the top factors effecting student achievement was uniform implementation of the program in every class. It is clear that there are important differences in the ways in which different teachers integrate technology into their classrooms and that those different approaches will produce very different results.

Differences in Building Implementation

Research reveals that simply providing technology is not sufficient to guarantee that laptops are actually used. One study found that students in five middle schools in Massachusetts were not using technology any more frequently than students in comparable non-laptop schools after three years of program implementation (Goodwin, 2011). Building administrators cannot expect for meaningful integration of technology into instruction to occur through a simple top-down mandate, and attempting to encourage laptop use through requirement rather than encouragement may ultimately backfire (Boardman, 2012). While teachers in one study agreed that flexibility is more beneficial than stringent mandates handed down by administration, they also admitted that such flexibility will produce inconsistent levels of implementation from classroom to classroom (Jones, 2013). Numerous contextual conditions can affect the success or failure of a one-to-one program including the schools' existing goals and visions (Fleischer,

2012) and the schools' values, demonstrating the need for a comprehensive approach to changing the culture of a school in order to produce meaningful changes (Cervantes et al., 2011). One comparative case study in particular concluded that two one-to-one programs were successful because they focused on supporting teacher pedagogy and developing technology infrastructures, while another program which expected the technology to produce outcomes on its own ultimately failed (Warschauer et al., 2014). Another qualitative study found that requiring teachers to use the laptops did not result in authentic changes in teachers' pedagogical practices (Blackley & Walker, 2015). All of these concerns reveal that actual implementation of a program can vary widely from classroom to classroom within any laptop program, and it is essential to measure the degree of implementation as a factor when attempting to attribute laptop programs to assessment outcomes (Weber, 2012).

Factors Influencing Implementation

The literature identifies numerous factors which can influence the frequency of use and the pedagogical effectiveness of a one-to-one laptop program. Content area may be one such factor. For example, Zuber and Anderson (2013) found that mathematics teachers used the laptops less frequently than other teachers, a finding which supported findings from previous studies cited in their literature review. A qualitative study of math teachers in the seventh year of a laptop program showed that even in the seventh year, the teachers had not effectively incorporated the laptops into the teaching and learning process (Blackley & Walker, 2015). Another study found that students perceived language arts and social studies as the subjects in which the laptops were used most frequently, and mathematics as the least (Burgad, 2008).

Teacher experience may be a factor as well. One study revealed that new teachers used technology less frequently than more established teachers (Jett, 2013). Another factor identified in the literature is teacher perception of student behavior. Participants in one study reported that they were less likely to use technology with students with behavior issues than with those who behaved more positively (Boardman, 2012). Another found that when teachers (specifically math teachers) perceived that the laptops distracted students from their math work they began to discourage their use, or reserve their use only for students were better behaved and self-motivated (Zuber & Anderson, 2013). Yet another study found similar results: While one participant believed that her well-behaved classroom was the perfect environment for computer use, another who believed that students' freedom when using computers was a threat to her control in the classroom did not find ways to integrate laptops into her classroom (Windschitl & Sahl, 2002). Other factors, such as a lack of technological knowledge, an overly crowded curriculum, and past computer use, are listed as other possible factors influencing levels of implementation in the classroom (Larkin & Finger, 2011).

Teacher attitudes and beliefs are also cited throughout the literature as important factors influencing the implementation of one-to-one laptop programs. If teachers do not buy-in to a laptop program, or if they harbor negative attitudes and beliefs about it, successful and effective implementation is very unlikely (Donovan et al., 2007; Gillard, 2011; Goodwin, 2011; Fleischer, 2012; Harris, 2010). One study in particular found that teacher beliefs were the most important factor influencing laptop integration, above all other independent variables identified (Inan & Lowther, 2010), and another found that teachers' beliefs about the role of technology in learning and in the lives of students substantially mediated teachers' instructional decisions regarding the use of technology in their classrooms (Windschitl & Sahl, 2002). Teacher openness to change was found to be highly explanatory in analyzing rate of adoption among particular teachers (Blau & Peled, 2012) Finally, Zuber and Anderson (2013) found that negative beliefs about the use of laptops presented a formidable barrier to wider adoption of one-to-one laptops by teachers. It is clear that teachers' perceptions are a key element of a one-to-one program effectiveness or its ultimate failure.

Other important factors influencing laptop program implementation are teacher motivation and desire for professional growth (Chandrasekhar, 2009), individual teachers' pedagogical abilities (Wong & Wettasinghe, 2012), and time for teacher learning and collaboration (Goodwin, 2011; Lindqvist, 2015). Teachers learning from other teachers in a collaborative atmosphere was found in one study to provide tools and strategies that could be put to immediate use in classroom instruction to facilitate successful program implementation (Boardman, 2012), and in another study the desire for collaboration was found to correlate to lower levels of personal concerns during a laptop implementation (Donovan & Green, 2010). Similarly, Pogany (2009) found that collaboration among teachers to assist in learning the new technology was among the most critical considerations when implementing a one-to-one initiative. This may be because intimidation due to a lack of confidence in technological knowledge and ability is a major barrier to effective integration, and that confidence correlates highly with time spent using technology in the classroom (Beeson et al., 2014). Technological knowledge has been found to be a strong indicator of instructional technology integration (Grant et al., 2005; Pack, 2013) and a lack of technological knowledge (Larkin & Finger, 2011) or limited technology skills (Zheng et al., 2016) have been identified as barriers to such integration. Many teachers report concerns that students are more knowledgeable using technology than they are (Ball, 2010; Jett, 2013; Niles, 2006). However, if teachers can move beyond the fear of students knowing more than they do they can learn from their students and the exchange of knowledge from student to teacher can help teachers adjust to new technologies (Ball, 2010;

Niles, 2006). It is clear that there are numerous individual factors which contribute to the effectiveness or ineffectiveness of efforts to integrate technology into the classroom during one-to-one laptop initiatives.

Technology, Pedagogy, and Content Knowledge

One theoretical framework which appears frequently in the educational technology literature is technological pedagogical content knowledge. First proposed by Mishra and Koehler (2006) as a merging of educational technology expertise with a teachers' pedagogy and content knowledge called TPCK (technological pedagogical content knowledge) and now more commonly referred to as TPACK (technology, pedagogy, and content knowledge), the framework has proven useful for researchers within the field of educational technology (Koehler & Mishra, 2009). The framework indicates that in order to effectively integrate technology into the classroom, teachers must understand the relationship between the content being taught, the teaching practices being employed, and the technology being used (Beeson et al., 2014; Mishra & Koehler, 2006; Koehler & Mishra, 2009).

This framework often has explanatory power, as in a qualitative study in which the difference in effectiveness of two teachers' implementation of a one-to-one laptop program was analyzed in terms of pedagogical visions and content knowledge (PCK) but the key insight emerged when their level of experience with technology (T) was interrelated to those constructs (TPACK) (Beeson et al., 2014). Similarly, Larkin and Finger (2011) found the construct useful when analyzing why teachers whose pedagogical content knowledge was strong were limited their implementation of a one-to-one laptop program due to their relatively weak technological knowledge. It also appears that the type of merging which the theory suggests, when actualized, may result in enhanced learning experiences for students, particularly in one-to-one laptop environments (Jett, 2013), and that it is a key factor in the successful implementation of such programs (Wong & Wettasinghe, 2012). It has also been shown to be a useful framework for the design, implementation, and evaluation of professional development programs within one-to-one laptop initiatives (Allan et al., 2010; Beeson et al., 2014).

Professional Development

Among the most important factors in a successful one-to-one laptop initiative is the quality of professional development provided to participating teachers and administrators (Abell Foundation, 2008; Alberta Education, 2010; Blackley & Walker, 2015; Hoyer, 2011; Klieger et al., 2010; Lindqvist, 2015; Pack, 2013; Pogany, 2009; Storz & Hoffman, 2013; Topper & Lancaster, 2013; Warschauer et al., 2014; Zheng et al., 2016). Merely providing students with laptops will not affect achievement scores (Bryan, 2011) or significantly impact instructional delivery (Whiteside, 2013) because district and school leaders must train teachers on the most effective ways to incorporate technology into their classrooms (Borja, 2006; Danielson, 2009; Wong & Wettasinghe, 2012) in order to introduce teachers to new possibilities that technology brings and to provide them with the technical know-how they need to carry them out (Spires et al., 2012). Such professional development, however, should not simply be focused on the acquisition of technology skills but instead must be focused on each teachers' educational goals and on finding ways to facilitate teaching and student learning through the use of technology (Anderson, 2007; Gillard, 2011). Training which focuses simply on how to use a specific technology tool leaves decisions regarding the actual implementation of such tools up to individual teachers (Beeson et al., 2014) and does not place the technology in the proper context to maximize efficacy. Effective professional development will focus on pedagogy first and technology second, not the other way around (McKeeman, 2008).

Some forms of short term professional development which focused on the teaching of specific technology tools out of context did not correlate with increased use of laptops during a one-to-one initiative (Staub, 2013). Many teachers have reported that out of context professional development focused on specific technology tools seems irrelevant to their classroom work (Beeson et al., 2014), which supports arguments for more personalized professional development (Lindqvist, 2015), training which is focused on each individuals' pedagogical and content-area-specific needs and goals (Jones, 2013; Klieger et al., 2010; McKeeman, 2008) and individual teaching concerns (Hall & Hord, 2001) rather than merely teaching technology skills. Teachers adopt technology at different rates and have different concerns at different points in time, and effective professional development is differentiated and aligned with each teachers' stage of technology adoption (Dobbs, 2005; Jones, 2013), his or her own particular needs and concerns (Donovan et al., 2007), and his or her individual level of technological expertise (Gillard, 2011; Marable, 2011). Effective professional development is also supportive and collaborative (Maninger & Holden, 2009; Weber, 2012). Since teachers hold the central role in facilitating laptop learning, the allocation of resources for professional development is a key factor in influencing teachers' laptop integration (Inan & Lowther, 2010) and improving student learning in laptop environments (Harris, 2010).

Professional development is time consuming and many teachers report that they need adequate time to be allocated to enable them to attend such trainings (Klieger et al., 2010). Yet many schools do not provide adequate time for teachers to receive adequate professional development when implementing one-to-one initiatives (Ball, 2010; Blackley & Walker, 2015; Storz & Hoffman, 2013; Warschauer et al., 2014). To be fully effective, such training should begin even before the computers are actually deployed (Milton & Canadian Education

Association, 2008; Plummer, 2012), should be ongoing (Jones, 2013; Plummer, 2012; Weber, 2012), should become an integral part of the day-to-day interactions of teachers (Boardman, 2012), and should occur in face-to-face sessions (Howard & Rennie, 2013) inside the school, where the actual teaching takes place (Klieger et al., 2010).

As new teachers enter the education field, it is important that teacher preparation programs do not ignore the need to prepare teacher candidates for the technology-rich environment in which they are likely to end up teaching (Jones, 2013). Ideally teacher preparation programs should try to incorporate one-to-one programs. One study found that a laptop program dramatically improved teacher candidates' technology skills and produced changes in their beliefs about the educational uses of educational technology, leading the researchers to conclude that non-laptop candidates were not sufficiently prepared for the tech-rich teaching environments of today's schools (Donovan, Green, & Hansen, 2012). Another group of researchers argued that field supervisors should provide teacher candidates with opportunities to apply instructional technology skills within field experiences in order to prepare them for the successful integration of technology into their teaching practices (Allsopp, McHatton, & Cranston-Gingras, 2009). Too often teacher candidates are taught educational technology separately from content and methods, creating difficulties when they are asked to combine that knowledge during their student teaching (Beeson et al., 2014). It is important however, that teacher preparation programs consider faculty readiness to participate in such a program before implementation (Donovan & Green, 2010).

CHAPTER THREE: METHODOLOGY

While a recent survey of research journals reveals that quantitative studies still dominate research in general, a growing awareness of the utility of qualitative methods has fueled a recent move away from purely quantitative methods in the social and behavioral sciences and in the field of education in particular (Alise & Teddlie, 2010). As part of this expansion of research methods in the applied human sciences a relatively new methodology known as mixed methods was established as a formal discipline as recently as the year 2000 and its growth in popularity was fueled by a pragmatic shift which emerged from a growing belief in the value of the triangulation of data from multiple sources (Caruth, 2013; Creswell, 2008; Lund, 2012) and the use of multiple inquiry tools to gain different perspectives on a research problem (Biesta & Burbules, 2003). It is within this tradition of mixed methods research that the author sought to position the present study.

Research Paradigm

There are many advantages to using mixed methods in education research. Qualitative findings can be subject to researcher bias (Chenail, 2011) when researchers, often unintentionally, focus on data which supports pre-existing notions or assumptions rather than those that challenge such assumptions, a phenomenon widely referred to in the psychological literature as confirmation bias. Such tendencies can be checked through the use of analysis strategies which systematically take into account the perspectives of many participants simultaneously and track the tendencies in that larger data set as a way of confirming (or disconfirming) qualitative observations and anecdotal evidence. Mixed methods research designs can increase the validity of inferences and conclusions drawn in a study through the convergence of both qualitative and quantitative analyses (Lund, 2012). This strategy combines the most powerful elements of qualitative and quantitative methods by combining the in-depth qualitative understanding of the context, attitudes, and opinions of participants with a systematic quantitative analysis of trends in participants' perceptions and/or behaviors (Creswell, 2008).

The philosophical roots of mixed methods research are grounded in pragmatism (Creswell, 2008; Lund, 2012). Although Creswell (2008) has argued that a solid grounding in a paradigm-based worldview is not essential or even necessarily relevant in mixed methods research, Hall (2013) contends that using the term *pragmatism* in a strictly utilitarian sense, without consideration of its philosophical underpinnings, is an overly simplistic way of avoiding explicit discussions of the paradigmatic implications of mixed methods research and should be avoided. The following discussion seeks to avoid such criticism by fully evaluating the methodology of the present study in the context of the larger paradigm discussions in order to clearly and explicitly establish its theoretical foundations and to engage in the development of a "more *philosophically nuanced pragmatism*" which has emerged in mixed methods research in recent years (Teddlie, & Tashakkori, 2011, p. 290, emphasis in original).

Despite the growing popularity of mixed methods research, there continues to be a perception among certain research methodologists that qualitative and quantitative research methods are fundamentally incompatible (Caruth, 2013; Lincoln, Lynham, & Guba, 2011; Lund, 2012). Indeed, some theorists continue to argue that quantitative research methods are grounded in positivism and a belief in realism and the search for objective truth, while qualitative research methods are grounded in constructivism and relativist epistemologies (i.e. Lincoln, Lynham, & Guba, 2011). However, this association of quantitative research with positivism does not appear to fit the actual beliefs and practices of quantitative practitioners. Morgan (2007) argues that early advocates of qualitative research, seeking to challenge what they perceived as a dominant paradigm which excluded their qualitative methods, labeled all quantitative research as falling within the paradigm of positivism, although the actual practices of quantitative practitioners of the time had little to do with the formal scientific philosophy known as logical positivism. Johnson and Onwuegbuzie (2004) argue that these qualitative purists (among whom he specifically identifies Guba, cited above) set themselves against a group of quantitative purists during the "paradigm wars" (p. 14), both camps advocating for the "incompatibility thesis" (p. 14) which posits that qualitative and quantitative methods are not compatible with each other based on fundamental epistemological grounds and therefore should not be mixed.

However, the belief in the incompatibility of qualitative and quantitative methods has been challenged by advocates of mixed methods research who ground their thinking not in positivism or constructivism, but in pragmatism. This uniquely American philosophical framework was first described by William James in a series of lectures beginning in 1907 as a "mediating way of thinking" between the competing schools of empiricism and rationalism (James, 1978, p. 26). One hundred years later, researchers drawing from this rich philosophical tradition are taking a similar approach to the competing claims of positivists and constructivists. Morgan (2007) refers to the belief in the incompatibility of qualitative and quantitative methods as "incommensurability" (p. 64) and argues that the notion of the incommensurability of qualitative and quantitative methods fails at every level of actual research practice, applying only to the most abstract and theoretical considerations of fundamental reality and truth. Similarly, Johnson and Onwuegbuzie (2004) argue for a compatibilist mixed methods approach based in a pragmatic focus on practical consequences in which researchers use the best available method for answering their research questions rather than focusing on differences based in abstract epistemological purism.

But such notions of the commensurability of qualitative and quantitative methods can be found even earlier in the education research literature. As early as the mid-nineties Mashhaddi (1996) observed that all studies (including purely quantitative experimental designs) are interpretive endeavors and that the history of science, even in the physical sciences, is better described in terms of the construction of metaphors, not the systematic discovery of truth. He argued that the post-modern realization of the interaction between the researcher and the researched within the field of educational research has rendered the association of quantitative scientific research with positivism untenable and that qualitative and quantitative methodologies and their associated paradigmatic groundings are not contradictory but complimentary (Mashhadi, 1996).

Emerging from his research within the field of physics education regarding the social construction of reality in the conceptualization of wave-particle duality in the minds of students, Mashhadi (1996) observed that despite positivistic claims to the contrary, quantitative research examines aspects of constructed reality, not objectively real phenomenon, showing that the identification of positivism with quantitative research was already being challenged in the mid-nineties. He offered the compelling example of a study in which quantitative methods were used to arrive at a qualitative appreciation of physics students' reasoning processes. This example is a model of the interweaving of concepts which have been considered distinct and incompatible in the past by "purists" (Johnson & Onwuegbuzie, 2004) but which can alternately be viewed as mutually compatible and even complimentary. Mashadi's (1996) insights lend themselves to notions of commensurability and confluence within and between qualitative and quantitative research practices. Seen through a pragmatic framework, abstract epistemological concerns and more practical concerns about methods can be integrated (Morgan, 2007). As William James put it, pragmatism has the power to bring scientific practice and abstract metaphysical philosophizing together to "work absolutely hand in hand" (James, 1978, p. 31). It may be that the mixed methods approach is an example of his vision come to fruition.

John Dewey's theory of pragmatism, which has been regarded as fundamental in the development of mixed methods education research, rejects dualistic notions of objective and subjective reality and eschews the search for absolute truths (Biesta & Burbules, 2003; Teddlie, & Tashakkori, 2011; Hall, 2013). Within this pragmatic framework, however, is an insistence upon aspects of realism which connect such research back to actual problems within a fluid, changing, and socially constructed, but none-the-less real realm of organism/environment interaction, a perspective sometimes referred to as "transactional realism" (Biesta & Burbules, 2003, p. 11; Hall, 2013, p. 17). For pragmatists, the notion that there is a real world and the notion that all individuals have their own unique interpretation of the world are neither incompatible or incommensurate (Morgan, 2007). This epistemological perspective can also be found in James's fusion of objective empiricism and subjective rationalism into the analysis of "practical consequences" (p. 44), and in his declaration that within pragmatism "Purely objective truth […] is nowhere to be found" (James, 1978, p. 37).

This pragmatic perspective, then, fits into neither the objective realism of the pure positivists or the subjective relativism of the pure constructivists. This perhaps explains the arguments that pragmatically-based mixed methods research is a-paradigmatic (Hall, 2013), that it traditionally lacks philosophical nuance (Teddlie, & Tashakkori, 2011) or that paradigmatic foundations are not necessarily relevant to mixed methods research (Creswell, 2008). Indeed, it seems difficult to place pragmatism appropriately or accurately within the paradigm framework created by Lincoln, Lynham, and Guba (2011) which defines competing paradigms such as positivism and constructivism in terms of differing positions within dichotomous categories such as realism vs. relativism and objectivist vs. subjectivist. These are categories within which pragmatism does not comfortably fit, and which it eschews as largely irrelevant to its unique metaphysical and methodological framework, so perhaps it is not a surprise that pragmatism is left out of Lincoln, Lynham, and Guba's (2011) chart depicting the framework of their understanding of the paradigm controversies.

The problem is perhaps best summed up in Guba's (1990) claim, made at the height of the paradigm controversies of the late twentieth century, "the only alternative to relativism is absolutism" (p. 18). This is an interesting dichotomy for a self-described constructivist to create. Although it perhaps serves the rhetorical purpose of identifying a fundamental difference between positivist and constructivist thinking, which lies at the heart of the paradigm debate in which he was engaged, like all such dichotomies, it is a false one. The very notion of relativism which he describes is defined in direct contrast to realism, which is the belief in a Real world which exists outside and independent of the human mind. This can be seen clearly in his definition of relativist constructivism in which he argues that reality does not exist outside of human perception but only "in the *minds* of constructors" (p. 27, emphasis added). In sharp contrast, Deweyan pragmatism does not fit comfortably in either the constructivist or realist camp because it posits a uniquely different metaphysical perspective in which mind and matter are never separate in the first place (Biesta & Burbules, 2003). Simply flipping the traditional objective vs. subjective dichotomy upside down doesn't address the real problem – which is the assumption of the efficacy of the very dichotomy in and of itself. For pragmatism reality is neither only in the mind nor out there separate from it – neither description fits.

This is not merely a semantic distinction. It is a fundamental re-construction of our understanding of reality and the Real through which the basic distinctions between positivists and constructivists are not merely rendered unimportant or irrelevant to pragmatist thinking, but through which the fundamental distinctions between them are rendered *non-existent*. It is not necessarily the case that pragmatic researchers are not interested in or want to find an easy way to avoid the philosophical paradigm discussions. Even those who do see the value in the philosophical grounding of educational research (e.g. Biesta & Burbules, 2003) find that the paradigm of pragmatism doesn't fit comfortably within the framework of that debate, because the differences which are being discussed and sometimes argued about are centered on functional concepts which for pragmatists lack any metaphysical reality.

The statement that reality exists "only in the mind" does not make sense, pragmatically speaking. There is no such thing as "only in the mind" because reality exists neither within the mind nor outside of it, but in a process called transaction which comes before the mind/body dichotomy can even be conceived. The word "mind" itself is merely a concept – a functional semantic distinction which is made only after reality emerges and which is not a metaphysically Real entity capable of manifesting any type of existence in and of itself, let alone all of reality. But, likewise, an objectively Real or absolute existence outside or separate from the process of transaction is equally nonsensical within the pragmatic metaphysics. Within the theoretical framework of pragmatism, the dichotomy of relative vs. absolute that Guba (1990) evokes becomes a distinction without a difference. Hence, there is a third alternative between the relative and the absolute which does not privilege either over the other because it recognizes neither – pragmatic humanism (Biesta & Burbules, 2003).

Biesta and Burbules (2003) describe Deweyan pragmatism as a combination of realism and constructivism. But the realism which pragmatism incorporates is not the naïve realism of the positivists. What is Real – that is what exists objectively and independent of human perception – is, by definition, impossible to perceive. Dewey himself argued, in recognition of the replacement of Newtonian physics with the new physics being explicated by scientists like Einstein and Bohr, that matter and objects could not be observed in a truly objective way, and that the only universal thing is the phenomenon of process itself (Biesta, & Burbules, 2003). As the physical sciences have continued to develop since the time of Dewey it has become more and more clear that classical physics is much less useful than quantum mechanics at enabling physical scientists to produce desired outcomes. Perhaps the most interesting recent example is found in the quantum imaging experiment conducted in Vienna in which a photograph of a cat-shaped cut-out was obtained from photons which had not interacted with the object itself (Lemos, Borish, Cole, Ramelow, Lapkiewicz, & Zeilinger, 2014). This result was predicted by the quantum principle of superposition but would be very difficult to explain in terms of classical mechanics (Gibney, 2014).

This is an interesting finding in the context of pragmatism – Biesta and Burbules (2003) cite Heisenberg's uncertainty principal as an example of the concept of transaction which they argue Dewey himself recognized in the theories of Bohr (and Heisenberg, of course, was Bohr's student). The idea is that the very process of observing subatomic particles effects their characteristics, meaning that observation itself is not a process of objectively observing the Real, but is a "natural event," or transaction, through which real experiences emerge (p. 27). It means that the question of "what is really there?" is unanswerable absent the consideration of "what happened?" But further, this experiment provides an excellent example of the usefulness of Dewey's pragmatism in explaining why such theories do not mean that researchers must abandon all aspects of realism in favor of radical subjectivity or complete relativism, and is one way in which pragmatism differs from pure constructivism.

For Dewey, knowledge is neither purely in the mind (subjective) nor related to the relationship between the Real and the True (objective). For Dewey knowledge is related to inference – which he describes as "taking up an attitude of response to an absent thing as if it were present" (qtd. in Biesta & Burbules, 2003, p. 47) which Biesta and Burbules (2003) explain in terms of the metaphor of smoke and fire – if one sees smoke one might infer that there is fire even though the fire is not present to one's immediate senses – and the resultant action of calling the fire department might bring about the desired consequence (i.e. the fire doesn't spread too far before it can be contained). In this example, one could argue that the observer had knowledge of a fire, knowledge which became pragmatically useful within the context of that transaction, although the fire itself was never observed directly. I would argue that it is this same process of pragmatic inference that is at work in the quantum imaging experiment. Based on the theory of quantum superposition, those scientists were able to infer that a certain consequence would result from a given transaction and their control of that transaction in such a way as to produce the desired effect (or consequence) *constitutes* knowledge. That is to say that the knowledge exists neither in a decontextualized form in their own minds (truth) nor outside of their perception in the Real world (Truth) – that knowledge exists within and emerges from the transaction itself. Another scientist who is familiar with the study might say that she or he "understands" the concept of quantum imaging, but only when that transaction is recreated by said scientist, such that another quantum image is generated, can Deweyan knowledge emerge. Hence the traditional dichotomy between Truth (what corresponds to the Real) and truth (what one believes) becomes meaningless when knowledge is defined in terms of the predictable consequences of a dynamic transaction.

Now the scientists can and did write up their paper, but it would be a mistake to assume their knowledge is "contained" within that paper, or even that it was contained within their minds when they wrote the paper – the paper is merely a functional set of cognitive symbols, like a road sign indicating a sharp turn ahead. The sign does not contain either the bend in the road itself or the ability to safely turn a car through a sharp turn but it can, if the sign is interpreted and consumed intelligently and deliberately, change an event such that a car drives safely around a bend and a desired effect is achieved. But again, it would be a mistake to think that the turn itself is Real – after all, the very idea of "turns in the road" only have meaning within the context of certain events in which vehicles drive along roads – and it would be a mistake to think that the knowledge of how to turn is real – that knowledge only has meaning within the context of actually turning a car through a bend in the road. If a driver successfully turns a vehicle safely through a sharp turn, then that ability to control those conditions and create the desired consequences within that context is knowledge and that transaction is Real – it is constrained by the conditions of the interaction between road and car and driver that are independent of anyone's perception of them (i.e. a crash would occur even if the driver was unconscious and therefore was unable to subjectively experience or mentally construct it). But it would be a mistake to say that it is True that after turning a car safely the driver now "knows how to drive a car through a sharp turn" because the next turn, the next situation, is always unique and unpredictable, and that knowledge will only exist within the context of another safe turn, never "in the mind" independent of any context.

But the quantum imaging experiment works on an even deeper level yet, because what is perhaps most fascinating about the whole thing is that it shows that "knowledge can be extracted by, and about, a photon that was never detected" (Lemos et. al., 2014). The photons that created the image were not the same photons that came into contact with the object – which is to say that the scientists were able to obtain information about a particle that they never actually detected. This is particularly interesting within the context of quantum superposition and the famous Schrodinger's Cat thought experiment in which a hypothetical cat, if unobserved, can exist in two states at once – both alive and dead. In other words these photons, if undetected, can be said to have "both gone and not gone through the object" (Gibney, 2014, p. 1). It is the act of observation itself which collapses quantum superposition – meaning that the very act of observation determines which of the possible transactions become Real. In other words, the life or death of the cat (or the path of the photon) is not Real until the moment of observation – its Realness emerges from the transaction itself. Dewey was aware of the early twentieth-century breakthroughs in particle physics which help explain these kinds of quantum behaviors and this phenomenon is clearly at the heart of Dewey's claim that if a system can be said to exist, the act of observation "modifies that preexisting something" which means that existence is an event, not a static thing (qtd. in Biesta & Burbules, 2003). The history of quantum mechanics since his time has only worked to confirm the effectiveness of pragmatic metaphysical conceptualizations in explaining and predicting quantum interactions.

It is essential to recognize that parallels between quantum weirdness and reality at the macrocosmic level in which we act as human beings are impossible and inappropriate to make, but I do think that this experiment serves as an interesting metaphor for why pragmatism works so well despite the fact that its claims are not True, and its objects are neither real nor Real. Just as one can infer the existence of fire from the observation of smoke and call the fire department to prevent a massive conflagration, or just as one can infer the existence of a sharp turn by observing a sign and press the brake pedal to slow down and prevent an accident, or just as one can infer the characteristics of photons which classical physics cannot explain and create an image of a cat; as researchers we can successfully infer, predict, and control transactions in order to produce desired consequences. And these transactions are Real in the sense that they do not exist "only in our minds" – they operate in ways that are independent of our perception of them. It is for this reason that pragmatism can be considered a type of realism. But our cognitive understanding of transaction *post hoc* is always true, never True, because actual knowledge only exists in the context of transaction itself. It is for this reason that pragmatism can be considered a type of subjectivism.

But it is not a naïve realism, nor is it a radical subjectivism. The main reason for this is that although truth is a human construction, it is constrained by Real transactions. If reality was purely subjective then anything would be possible and any claim that coalesced around a consensus could be considered true. But that is not what pragmatic theory indicates. No matter how convinced a hypothetical group of sailors might be that the Earth is flat, a ship sailing around it can and will circumnavigate the Earth rather than fall off the edge of it. The transaction there is Real, our beliefs about it won't change how sailing around the world works. And if we don't ever test an existing consensus to determine whether it creates desired consequences, we can never move past the superstitions and limitations of "common sense" in order to change our interactions with the world in specific, desirable ways. In other words, our socially constructed reality (knowledge) is always already constrained by an existing course of events, one which we can potentially control in certain ways, but cannot "construct" out of nothing purely in our minds, as radical subjectivism would suggest (Biesta & Burbules, 2003).

A pure constructivist, placed in the time of Galileo, would conduct his or her research through the co-construction of reality coalescing around consensus and inevitably conclude that the Sun circles the Earth – after all that is the real and "common sense" experience which almost all human beings in that context would certainly be able to agree upon. That is the trap of relativism. It is only by testing that cognitive map and using it in order to infer the behavior of the other planets in the solar system in a transaction between scientist, telescope, and reflected light, that Galileo was able to understand that the socially constructed model of the solar system prevalent in his own time failed to achieve the desired results. No amount of social construction of truth or purely subjective experience of the real can ever produce knowledge by itself. But neither can objective observations of the Real ever produce True knowledge. Knowledge emerges from transaction, and when Galileo made a new set of inferences based upon a new model, one which was not part of the socially constructed reality of his time, then and only then was he able to infer the motion of the planets in a way that produced the desired consequence (i.e. his model matched his observations of their motions). Scientific progress depends upon both questioning the Truth and questioning socially constructed reality – that is where its power lies. And neither objectivism nor relativism can fully explain that power. Because they both begin their explorations after a fundamental mistake – the dichotomization of mind and matter – each sees only part of the whole picture. Only the cognitive construct of pragmatism, embodied in modern scientific method, can account for both the subjective nature of truth and the inevitable influence of the Real on human actions.

Research Design

In the context of the preceding discussion, an explanation of and justification of this study's research design can be formulated. The introduction of laptops into an educational environment is bound to produce changes in that environment. The transaction between students and computers will operate in ways which may or may not promote the goals of a given school or school district. Numerous studies have been conducted in an attempt to determine what the consequences of one-to-one laptop programs have been within various different contexts, and certain conclusions have been reached. It seems clear based on the existing data that a one-to-one laptop program can help to promote the development of twenty-first century skills (Abell Foundation, 2008; Allan, Erickson, Brookhouse & Johnson, 2010; Danielson, 2009; Greenwood, 2007; Harris, 2010; Hoyer, 2011; Jett, 2013; Lowther, Inan, Ross, & Strahl, 2012; Pogany, 2009; Rousseau, 2007; Sauers, 2012; Warschauer, 2007). If the goal of a school district or individual school is to promote the development of such skills among students, then a laptop program may be a warranted investment. What was much less clear, however, was whether such a program could be expected to increase reading achievement. The existing data at the time of this study was far from conclusive, and more information was needed before we could make any warranted assertions regarding the relationship between the use of computers by students for learning and reading achievement (Storz & Hoffman, 2013).

Part of the problem has been that learning is a complicated process and it is not always clear what influence, if any, computers have had on student achievement tests. Some schools or districts might provide laptops to students, but that is not a guarantee that laptops have actually beeen used by teachers or students on a consistent basis. This means that if the distribution of laptops by a school or district has not resulted in system-wide increases in test scores it is not immediately clear whether that is because computer use does not increase test scores or whether that is because the computers were not used consistently enough by students outside the classroom and/or by teachers in the classroom in order to produce a detectable increase. Likewise, if an increase in achievement is observed, it is not clear whether the increase was due to the laptops or other educational factors which may have influenced student achievement. What was needed was a study which directly related reported student levels of computer use and reading achievement scores in order to determine whether a correlation could be found. Some preliminary data indicated that there might be direct correlations between actual student use and increased reading achievement (Abell Foundation, 2008; Hansen, 2012), but more evidence was needed. Therefore, this study was designed to test whether high levels of usage of one-to-one laptop computers for learning is correlated with increased reading achievement scores.

A mixed methods research design grounded in the theory of pragmatism provided a theoretical framework from which both quantitative and qualitative methods were used in concert, to explore the impact on reading achievement of providing one-to-one laptops to high school students in a public school setting. The initial quantitative findings which correlated the reported levels and types of laptop use reported by students with reading achievement scores was then compared to the qualitative exploration of the teachers' perspectives regarding the barriers and opportunities for integrating the laptops into the learning process. This triangulation of qualitative and quantitative data lends increased validity to this study's findings (Caruth, 2013; Lund, 2012). The weaknesses of each approach were offset by the strengths of the other. That is to say that the quantitative ability to answer questions concerning "how much?" were balanced with the qualitative endeavor to understand "why?" (Caruth, 2013). Therefore, quantitative findings, such as the significantly less frequent use of the laptops in math classes, for example, were able to be compared to qualitative data explaining the unique barriers to laptop use expressed by math teachers. This triangulation therefore provided much more insight than could have been gained through either quantitative or qualitative methodologies alone.

While the quantitative study was able to provide insight into how the laptops were being used and how often, and were able to establish some correlations between those activities and reading achievement, it was the qualitative data that explained "why." Through mixed methods research grounded in pragmatism, the researcher sought to create coherence between the abstract world of the researcher and the hands-on world of the practicing educator.   By including the voices of teachers and the sharing of their lived experiences within the laptop program, a more complete and thorough understanding of the laptop program and the implications of these findings for future practice was discovered, which enriched and added to the valuable quantitative findings produced through the statistical analysis of the survey data regarding student laptop use and reading achievement.

Research Setting

The study was conducted in a comprehensive high school with 1,600 students in a suburban setting. Of the 97 teachers employed at the school, 68 held a master's degree or above. The student body was 30% minority; including 22% Hispanic, 3% Asian, and 2% African American enrollment and 32% of the students qualified for free or reduced lunch at the time the study was conducted.

The school was in the fifth year of a one-to-one laptop initiative. Five years earlier the school district purchased laptops for every freshman student in the building, and each subsequent year they continued to provide laptops for the incoming freshman class. As a result, at the time of the study, in the fifth year of the program, every student at the school (except for a very small number who for various reasons opted out or were excluded from the program) had 24-hour access to a laptop and free wireless Internet access while at school. In addition, each teacher, administrator, and counselor had been provided with a laptop for their own use. This program met the definition of a one-to-one laptop initiative offered by Penuel, presented above (Abell, 2008; Fleischer, 2012).

Sampling

Initial data on the usage of the laptops was gathered through a survey given to all 9th and 10th grade students regarding their computer usage levels during the school year in which the study was conducted (see Appendix E). The survey was administered in May of that year, asking students how the laptops had actually been used throughout the course of that school year. In addition, data concerning student reading achievement as measured by the MAP reading test were compared to the student usage data in order to discover correlations between reported types and levels of laptop usage and reading achievement. Lastly, three teachers were interviewed regarding their usage of the laptop computers in their classes, their perceptions of the opportunities the laptop program provided, and the barriers to the use of the laptops that they perceived (see Appendix B).

Sampling was limited by student participation rates in the survey and the availability of MAP reading scores for students who responded to the survey. Teacher interview participants were selected purposively to provide a sample of teachers with a variety of different self-reported usage levels, and in order to include at least one teacher who taught students at each grade level and at each of the three ability grouping levels at the school.

Data Collection

There were three different methods of data collection in this study. The first was student surveys which sought to measure each student's reported types and levels of usage of the district-issued laptop computer both inside and outside of school. The second method was an in-depth qualitative interview conducted with each of the three individual teachers. Finally, reading achievement data was collected based on the Measures of Academic Progress (MAP) tests which were administered to each student in the spring of that same school year.

Validity and Reliability

Validity is the most important consideration when evaluating a test (Wang, Jiao, & Zhang, 2013; Wang, McCall, Jiao, & Harris, 2013). Therefore, it is essential that when choosing a reading assessment there are reasonable assurances as to the validity of that assessment in measuring the targeted construct. The MAP reading test uses an item response theory (IRT) model based on the premise that student responses to individual items, as grouped by specific goal areas within the construct domain, can reveal systematic relationships which can be explained by the effect of the unitary latent trait (Wang, McCall, Jiao, & Harris, 2013). Goal areas are defined by individual state standards, to which the MAP test is systematically aligned. In Colorado those goals are reading strategies, comprehending literary texts, comprehending informative texts, comprehending persuasive texts, and word relationships and meanings (Wang, Jiao, & Zhang, 2013; Wang, McCall, Jiao, & Harris, 2013).

The MAP reading test is a computerized adaptive test (CAT) or computer-adaptive assessment, which means that the computer analyzes the students' answers and adjusts the difficulty of items in order to specifically target the student's ability level (Woodworth, 2011). This design can help to decrease the inaccuracy of standardized tests for those students whose ability level is significantly above or below grade-level, for whom the test material might otherwise be either inaccessible or overly easy, resulting in measurement error and making accurate measures of student growth impossible (Woodworth, 2011). However, this design presents a problem when seeking to confirm construct validity (i.e. the accuracy of the test items in measuring the single latent factor of reading achievement) through factor analysis. Because the individual test items vary from student to student and the ratio of test length to item bank count is around 50, the percent of missing data will be as high as 98%, making factor analysis results uninformative (Wang, McCall, Jiao, & Harris, 2013).

Conducting confirmatory factor analysis at the cluster level provides one possible solution to this dilemma, because it enables researchers to compare items which are part of the same goal or sub-content cluster, creating increased covariance and reducing missing data to manageable levels. A study which used a random sample of 20% of all available MAP score data in 10 different states, including Colorado, found compelling evidence of the construct validity and latent construct coherence of the MAP test when applying this cluster-level analysis strategy for conducting confirmatory factor analysis (Wang, McCall, Jiao, & Harris, 2013).

Another possible way to verify construct validity is to correlate MAP scores with other desirable outcome scores, such as those produced on college-readiness exams such as the ACT. If one of the goals of achievement tests is to measure student growth in relation to college-readiness goals, then this could confirm the external validity of the MAP achievement test as well as the construct validity of the latent factor of reading achievement. One such study analyzed correlations between MAP scores and college-readiness tests of 26,000 students from 140 schools in three states and found that MAP reading scores predicted student ACT reading scores with 78% accuracy when taken during the same term (Northwest Evaluation Association, 2012). Because that study was conducted by the association which produces the MAP test, independent confirmation of these findings was sought and found in a study which compared 895 students' ACT reading scores with their performance on the 10^{th} grade MAP reading test. A bivariate correlation showed a strong positive relationship between the two scores ($r = .680$; $p < .01$) leading the researcher to conclude that MAP scores can be used to predict scores on the ACT test (Brown, 2014). These three studies taken together provide compelling evidence that the MAP reading test is a valid and reliable indicator of actual student reading achievement.

Data Analysis

Analysis of the qualitative data obtained in interviews of participating teachers was conducted through the constant-comparative method of coding qualitative interviews as described by Boeije (2002), which is based on four criteria: (1) the data involved and the overall analysis activities, (2) the aim, (3) the results and (4) the questions asked. This model provided a systematic process for coding qualitative interviews which included an open coding process, the development of themes through an analysis of the codes within each interview, then a comparison of the common themes between each interview, and finally a comparison of the findings of the qualitative analysis with the quantitative findings of this study. It is claimed that adopting this kind of purposeful and step by step approach to data coding and analysis increases the credibility of that qualitative analysis (Boeije, 2002).

Initial analysis of the student surveys was conducted using descriptive statistics. A frequency table was generated to show students' reported usage in each subject area as well as their usage of laptops for each of the activities on the survey instrument.

Between groups comparisons using the independent samples *t*-test were conducted for those students who participated in the study and those who did not participate, but for whom

MAP scores were available, to determine whether there was a significant difference between the sample population and the population of students in the district as a whole. A second independent samples *t*-test was conducted to compare the use of laptops for homework by students who reported having access to the Internet at home and those who reported that they did not have reliable access at home in order to determine whether at-home Internet access was related to the frequency with which students use their laptops for homework.

Correlations between frequencies and types of laptop use with reading achievement were then calculated using the Pearson product moment correlation statistic for items that were not markedly skewed, and the Spearman *rho* statistic for those that were found to be highly skewed. The following correlations with scores on the MAP reading test were then calculated:

1. Reported usage of the laptops in English language arts, science, social studies, and math class.
2. Reported usage of the laptops outside of the classroom for both homework and other learning purposes.
3. Reported usage of personal computers or other devices not supplied by the district for learning purposes.
4. Reported usage of the laptops for each of the purposes listed on the student survey instrument.

Finally, two multiple regression analyses were calculated in order to develop models which could be used to predict student reading achievement based on the ways in which students reportedly used their district-provided laptops:

1. Types of reported usage positively correlated with reading achievement.
2. Types of reported usage negatively correlated with reading achievement.

CHAPTER FOUR: FINDINGS

This study examined the use of laptops by teachers and students in a mature one-to-one laptop program at a suburban high school. The findings are organized according to the research questions outlined in Chapter One. First, questions one and two are examined, which ask about student frequency of use and the ways in which students use the laptops and the relationship between that usage and achievement scores on the MAP reading test. Next, questions three and four are explored, which ask about the resources and skills which have enabled teachers to incorporate the laptops into their classroom activities and instruction and the barriers and obstacles which have discouraged or limited the incorporation of the laptops into their classroom activities and instruction. The first two questions were explored using quantitative research methods while the third and fourth were examined using qualitative research methods, in keeping with the mixed methods design of the study described in Chapter Three.

Three hundred and sixty-six students in the 9^{th} and 10^{th} grade at the school took the laptop usage survey during their English classes. Six parents opted their student(s) out of the survey; one parent opting out two students, for a total of seven parent opt-outs. In addition, nine students selected “I do not want to participate in the study at this time” after reading the consent document on the first page of the survey. There were also two English teachers who opted their students out of the survey, citing insufficient time to complete the surveys during class time. The frequency table and other descriptive statistics are pulled from the 366 students who participated in the survey, but only 354 of those students had valid MAP reading scores which could be matched with their survey results and used for correlation and regression analysis.

Descriptive Statistics

The types and frequencies of district-provided laptop use reported by students in the surveys are summarized in Table 1. The survey data indicates that students are most likely to use their laptops in their English Language Arts class, with 302 students (83%) reporting that they use their laptops in their English class every day or most days. Students reported that they are least likely to use the laptops in their Math class, with only 9 students (2.5%) reporting that they use them every day or most days and 309 students (84%) reporting that they never or rarely use their laptops in Math class.

The survey also indicates that students are likely to use the laptops outside of class for homework or learning purposes. 267 students (73%) said they use their laptops every day or most days for homework and 257 (70%) reported using their laptops for learning purposes other than homework or classwork every day or most days. In addition, more than half of the students (190, 52%) reported using their laptops for conducting research every day or most days. Despite the fact that 84% of students report that they rarely or never use their laptops in math class, 71 students (19%) reported accessing math resources online every day or most days and an additional 113 students (31%) said they sometimes access math resources online.

The most frequent non-academic activity reported in the survey was watching videos, which 174 students (48%) said they did every day or most days. In addition, 71 students (19%) reported playing single-player games every day or most days and 75 students (20%) reported social networking with friends every day or most days. It is important to note that the district server attempts to block gaming and social networking sites on the district-provided laptop computers, but limited access to YouTube is available to high school students on their laptops. In addition, some students might be reluctant to report playing games or engaging in social

Table 1

Reported Frequency of Laptop Usage by Type (*N* = 366)

Category	Every Day	Most Days	Sometimes	Rarely	Never
English Class	98 (27%)	204 (56%)	52 (14%)	11 (3%)	1 (0.2%)
Science Class	75 (20%)	67 (18%)	160 (43%)	55 (15%)	9 (2%)
Social Studies Class	29 (8%)	64 (17%)	182 (50%)	63 (17%)	8 (2%)
Math Class	1 (0.2%)	8 (2%)	48 (13%)	222 (62%)	87 (24%)
Homework	130 (36%)	137 (37%)	74 (20%)	20 (5%)	5 (1%)
Learning Outside the Classroom	140 (38%)	117 (32%)	76 (21%)	28 (8%)	5 (1%)
Creative Writing	30 (8%)	71 (19%)	121 (33%)	75 (20%)	69 (19%)
Writing Blogs, Posts, or Comments	23 (6%)	30 (8%)	46 (13%)	74 (20%)	193 (53%)
Conducting Research	52 (14%)	138 (38%)	125 (34%)	41 (11%)	10 (3%)
Analyzing Information	35 (10%)	96 (26%)	153 (42%)	63 (17%)	19 (5%)
Contributing to Online Databases	31 (8%)	53 (14%)	76 (21%)	64 (17%)	142 (39%)
Collaborating with Same School Peers	31 (8%)	98 (27%)	134 (37%)	68 (19%)	35 (10%)
Collaborating with Different School	15 (4%)	45 (12%)	90 (24%)	85 (23%)	131 (36%)
Social Networking with Experts	27 (7%)	30 (8%)	52 (14%)	72 (20%)	185 (50%)
Social Networking with Celebrities	20 (5%)	16 (4%)	40 (11%)	58 (16%)	232 (63%)
Math Resources	15 (4%)	56 (15%)	113 (31%)	112 (30%)	70 (19%)
Reading Political News	14 (4%)	50 (14%)	77 (21%)	113 (31%)	112 (30%)
Reading Sports News	14 (4%)	35 (7%)	54 (15%)	87 (24%)	176 (48%)
Reading about People	17 (5%)	45 (12%)	93 (25%)	92 (25%)	119 (32%)
Watching Videos	71 (19%)	103 (28%)	110 (30%)	51 (14%)	31 (8%)
Multi-Player Games	29 (8%)	27 (7%)	36 (10 %)	61 (17%)	213 (58%)
Single-Player Games	32 (9%)	39 (11%)	73 (20%)	94 (25%)	128 (35%)
Social Networking with Friends	55 (15%)	20 (5%)	36 (10%)	48 (13%)	207 (56%)
Social Networking with Family	34 (9%)	24 (7%)	34 (9%)	48 (13%)	226 (61%)
Reading Messages	69 (19%)	63 (17%)	84 (23%)	68 (18%)	82 (22%)
Other	53 (14%)	47 (13%)	84 (23%)	56 (15%)	126 (34%)

networking activities when taking a survey in a classroom environment in which those activities are discouraged, so this data should not be generalized or construed as evidence reflecting high school student Internet behaviors in general.

Students have free wireless Internet access for their laptop computers while at school, but when away from school they must connect to another source in order to access the Internet. 323 (88%) of survey participants reported that they had Internet access at home, while 34 students (9%) said that they did have access but it was slow or unreliable, and 9 students (2.5%) reported that they did not have Internet access at home.

Between Groups Comparisons

An independent samples *t*-test was conducted in order to determine whether there is a significant difference between the mean reading scores of participants and non-participants. Available MAP scores for non-participating 9th and 10th graders from throughout the district (N = 1347) were compared with MAP scores for students who took the laptop usage survey (N = 354). The average test score for participating students (M = 231.34) was higher than the average test score for non-participating students (M = 229.59) for a difference of 1.75 between the means of the two groups, and the difference was statistically significant at the $p < .05$ level, but not at the $p < .01$ level ($p = .044$). The standard deviations, t score, and degrees of freedom for the comparison of average MAP score between participants and non-participants are reported in Table 2. It should be noted that the average MAP reading score for participating students was higher than the district average reading score, but with a data set of this size whether the difference is large enough to conclusively determine that the sample population is significantly different from the population of the district as a whole is indeterminate.

Table 2

Comparison of Participants' and Non-Participants' MAP Reading Scores

Group	*M*	*SD*	*t*	*df*	*p*
			-2.021	705.70	.044*
Participants	231.34	13.49			
Non-Participants	229.59	17.68			

Note. The *t* and the *df* were adjusted because the variances were not equal.
*Significant at the $p < .05$ level

A second independent samples *t*-test was conducted to measure the difference in the rate of usage of the laptops for homework between participating students who reported that they had reliable Internet access at home ($N = 323$) and those who reported either that they did not have access at home or who said that it was very slow or unreliable ($N = 43$). The average rate of usage for homework among students with reliable Internet access at home ($M = 3.02$) was slightly higher than the average rate of usage for students without reliable Internet access at home ($M = 2.86$) for a difference of 0.16 between the means of the two groups, but the difference was not statistically significant ($p = .296$). The standard deviations, *t* score, and degrees of freedom for the comparison on the use of the laptops for homework among students with Internet access at home and those who do not have access at home are reported in Table 3.

Correlations

Correlation statistics were used in order to measure any associations between reading achievement scores and types and frequencies of laptop usage by students. Because some of the data categories were markedly skewed (skewness > 1.000) Spearman Rho correlations were used for some of the independent variables. Pearson correlations were used for independent variables with skewness < 1.000. Student scores on the spring MAP test, reflecting their reading level toward the end of the school year, were used for all correlations reported below.

Table 3

Comparison of Use of Laptop for Homework for Students with Internet Access and without Reliable Internet Access at Home

Group	*M*	*SD*	*t*	*df*	*p*
			1.046	364	.296
Do Have Access	4.02	0.934			
No Reliable Access	3.86	1.060			

Note. The *t* and the *df* were not adjusted because the assumption of variances was not violated.

Correlations were also run using growth scores, which measured the change in each student's reading score from fall to spring. No significant relationships were found between any of the independent variables and reading growth scores and therefore those statistics are not reported here. Reading growth scores were very highly skewed (skewness = 2.958) in contrast with spring reading achievement scores which were approximately normally distributed (skewness = -0.520).

Pearson correlations between approximately normally distributed variables and reading achievement are reported in Table 4 below. The strongest positive correlation was found with the use of the laptop computer for doing homework ($r = .339$, $p < .001$). This is a medium or typical effect size in the social sciences according to Cohen (1988). There was also a strong positive correlation with using the laptop for outside learning, which includes self-guided learning that is unrelated to actual homework or classwork ($r = .164$, $p = .002$). This is a small or smaller than typical effect size (Cohen, 1988). The only other independent variable which showed a statistically significant positive correlation with reading achievement was accessing math resources online ($r = .117$, $p = .027$), which was significant at the $p < .05$ level with a small or smaller than typical effect size (Cohen, 1988).

Table 4

Pearson Correlations with Spring Reading Scores (*N* = 354)

Reported Usage	*r*	Sig.	*M*	*SD*
Homework	.339	.000**	4.00	0.948
Outside Classroom Learning	.164	.002**	3.98	1.010
Non-Provided Computer Learning	-.026	.632	3.41	1.288
English Language Arts Class	-.058	.273	4.06	0.746
Science Class	-.075	.162	3.40	1.047
Social Studies Class	-.105	.049*	3.18	0.873
Math Class	.054	.309	1.96	0.689
Creative Writing	-.099	.064	2.78	1.186
Conducting Research	-.021	.694	3.50	0.953
Analyzing Information	-.029	.588	3.18	1.002
Contributing to Online Databases	-.349	.000**	2.37	1.349
Collaborating w\ Same School Peers	.024	.657	3.07	1.077
Collaborating w\ Different School	-.136	.010*	2.27	1.190
Accessing Math Resources	.117	.027*	2.56	1.082
Reading Political News	.045	.400	2.29	1.142
Reading about People	-.137	.010*	2.30	1.176
Watching Videos	-.008	.888	3.37	1.184
Playing Single-Player Games	-.059	.265	2.32	1.285
Reading Messages	.033	.539	2.94	1.404

*Significant at the $p < .05$ level
**Significant at the $p < .01$ level

The strongest negative correlation was found with using the laptop to contribute to online databases, which was phrased in the survey as: "Contributing Research, Data, or Information to Online Databases (i.e. Wikipedia, Guitar Tab Archive, MobyGames, GameRankings, Internet Movie Database, etc.)" which showed a statistically significant negative relationship to reading achievement ($r = -.349$, $p < .001$) with a medium or typical effect size (Cohen, 1988). Another negatively correlated independent variable was collaboration with peers from a different school, phrased in the survey as: "Collaborating with peers from outside FCHS on creative or intellectual projects" which showed a statistically significant negative relationship to reading achievement ($r = -.136$, $p = .010$) with a small or smaller than typical effect size. Reading about people was also negatively correlated with reading achievement, an activity phrased in the survey as: “Reading about People/Bands/Actors/Artists” which showed a statistically significant negative relationship to reading achievement (r = -.136, p = .010) with a small or smaller than typical effect size (Cohen, 1988).

The only in-classroom use of the laptop which showed a statistically significant correlation with reading achievement was the use of the laptops in social studies class (r = -.105, p = .049) with a small or smaller than typical effect size (Cohen, 1988). Use of the laptops in English language arts class and science class also showed negative, though not statistically significant, correlations with achievement and only the use of laptops in Math class showed a positive relationship, although that relationship was not statistically significant either. This finding is interesting and will be explored further in the qualitative data section of this chapter and will be discussed in more detail in chapter 5.

Seven of the independent variables were skewed (skewness > 1.000), which indicated that they were not normally distributed, so the Spearman rho statistic was used. Those nonparametric correlations are reported in Table 5. All seven of these independent variables showed a statistically significant negative correlation with reading achievement. Social Networking activities were divided into four categories for the purposes of the survey, and all four of those categories were negatively correlated with reading achievement. The largest effect size was with the category social networking with celebrities, phrased in the survey as: “Connecting with celebrities (i.e. retweeting, @tagging, posting comments on YouTube or Instagram, liking or re-posting, etc.)” which showed a statistically significant negative

Table 5

Spearman Correlations with Spring Reading Scores (*N* = 355)

Reported Usage	*rho*	Sig.	*M*	*SD*
Writing Blogs, Posts, or Comments	-.134	.012*	1.97	1.245
Social Networking with Experts	-.182	.001**	2.03	1.287
Social Networking with Celebrities	-.199	.000**	1.73	1.156
Reading Sports News	-.127	.016*	1.97	1.157
Playing Multi-Player Games	-.134	.012*	1.90	1.302
Social Networking with Friends	-.120	.024*	2.10	1.491
Social Networking with Family	-.156	.003**	1.88	1.333

*Significant at the $p < .05$ level
**Significant at the $p < .01$ level

relationship with reading achievement ($r = -.199$, $p < .001$) with a small to medium effect size (Cohen, 1988). All four categories of social networking activities had a statistically significant negative correlation with reading achievement, as did playing multi-player games ($r = -.134$, $p = .012$), reading sports news ($r = -.127$, $p = .016$), and writing blogs, posts, or comments ($r = -.134$, $p = .012$).

Multiple Regressions

Based on the findings from the correlation statistics, simultaneous multiple regressions were conducted in order to determine the best predictors of both high reading achievement and low reading achievement among 9th and 10th grade students. Because students at the school are grouped into their classes by reading level, which might have influenced the in-class usage data, only outside-of-class activities were included in the multiple regressions (see qualitative section and Chapter 5 for further explanation and analysis of this issue). These models were designed to help determine which types of student-controlled usage of the laptops were most predictive of both high and low reading achievement.

Initially the simultaneous multiple regression designed to predict low reading scores was run using all 15 of the non-classroom independent variables which showed negative *r*-scores on the Pearson or negative *rho*-scores on the Spearman statistics, even if they were not statistically significant. After the initial regression was conducted it was determined that several of the independent variables were highly correlated with each other, which is not desirable because it could indicate a problem with multicollinearity (Morgan, Leech, Gloeckner, & Barrett, 2007). When high intercorrelations ($r > .500$) between predictor variables were found, the independent variable which most significantly contributed to the model was retained while the other was rejected, in keeping with the concept of parsimony, which indicates that in simultaneous multiple regression models the smallest number of predictors needed should be used (Morgan, Leech, Gloeckner, & Barrett, 2007). Through this process of elimination, the predictor variable conducting research was eliminated and analyzing data was retained. The variables social networking with celebrities, social networking with friends, and social networking with family were also eliminated, and social networking with experts was retained. Finally, single-player games was eliminated and multi-player games was retained.

The resulting model was run again with the ten remaining variables. Although multicollinearity had been eliminated, some predictor variables were not contributing to the overall effect size, and it was perceived that further applying the concept of parsimony (Morgan, Leech, Gloeckner, & Barrett, 2007) could result in a more efficient model. Therefore, all of the variables with a $p > .500$ (creative writing, collaborating with different school peers, reading sports news, and reading about people) were eliminated and the simultaneous multiple regression was conducted one more time with the six remaining predictor variables. The means and standard deviations, as well as the intercorrelations can be found in Table 6, and the beta coefficients of the final simultaneous multiple regression statistic are reported in Table 7.

Table 6

Pearson Intercorrelations for Predictors and Reading Achievement (*N* = 354)

Variable	*M*	*SD*	On. Dat.	Videos	Blogs	Soc. Net.	Games	Data
Reading Achievement	231.34	13.491	-.349**	-.008	-.114*	-.188**	-.114**	-.029
Predictor Variable								
Online Databases	2.37	1.245	- -	.127**	.424**	.246**	.131**	.401**
Watching Videos	3.37	1.184		- -	.208**	.316**	.355**	.213**
Blogs or Posts	1.97	1.245			- -	.444**	.166**	.286**
Social Networking	2.03	1.287				- -	.316**	.172**
Playing Games	1.90	1.302					- -	.110*
Analyzing Data	3.18	1.002						- -

*Significant at the $p < .05$ level
**Significant at the $p < .01$ level

Table 7

Simultaneous Multiple Regression Analysis Predicting Low Reading Achievement (*N* = 354)

Variable	*B*	*SEB*	β
(Constant)	235.544	2.680	- -
Contributing to Online Databases	-3.965	.574	-.397**
Watching Videos	0.883	.624	.077
Writing Blogs, Comments, or Posts	0.883	.642	.082
Social Networking	-1.508	.608	-.144*
Playing Games	-0.963	.559	-.093
Analyzing Data	1.685	.738	.125*

Note. $R^2 = .165$; $F(6, 347) = 11.413$, $p < .001$
*Significant at the $p < .05$ level
**Significant at the $p < .01$ level

The combination of variables to predict low reading achievement scores was statistically significant, $F(6, 347) = 11.413$, $p < .001$. The R value was .406, which according to Cohen (1988) is a medium to typical effect size in the social sciences. The adjusted R^2 was .150. This indicates that 15% of the variance in reading achievement can be explained by the model.

Contributing to online databases was the most significant predictor ($p < .001$). Social networking ($p = .014$) and analyzing data ($p = .023$) also significantly contributed to the prediction. Although the other three variables did not significantly contribute, removing any one of them caused a decrease in the *R* value of the resulting model, leading the researcher to conclude that this is the most efficient model for predicting low student reading achievement that could be generated with this data set.

There were only six non-classroom usages of the laptops which had positive relationships with reading achievement, and only three of them were significant (doing homework, outside of the classroom learning, and accessing math resources). The second simultaneous multiple linear regression was run using all six of the positively related independent variables, but a high intercorrelation between homework and outside classroom learning ($r = .601$) resulted in outside reading being removed, creating a five-predictor model, the means, standard deviations, and intercorrelations of which are reported in Table 8 and the beta coefficients of which are reported in Table 9.

Table 8

Pearson Intercorrelations for Predictors and Reading Achievement (*N* = 354)

Variable	*M*	*SD*	Homwrk	Pol. News	Messages	Collab.	M. Res.
Reading Achievement	231.34	13.491	.339**	.045	.033	.024	.117*
Predictor Variable							
Homework	4.00	0.948	- -	.253**	.190**	.275**	.324**
Reading Political News	2.29	1.142		- -	.234**	.258**	.359**
Reading Messages	2.94	1.404			- -	.179**	.143**
Collaborating w/ Peers	3.07	1.077				- -	.258**
Math Resources	2.56	1.082					- -

**Significant at the $p < .01$ level

Table 9

Simultaneous Multiple Regression Analysis Predicting High Reading Achievement (N = 354)

Variable	*B*	*SEB*	β
(Constant)	213.978	3.294	- -
Homework	5.127	.783	.360**
Reading Political News	-0.423	.660	-.036
Reading Messages	-0.186	.504	-.019
Collaborating with Peers	-0.895	.677	-.071
Accessing Math Resources	0.430	.701	.034

Note. R^2 = .122; F (5, 348) = 9.687, $p < .001$
**Significant at the $p < .01$ level

The combination of variables to predict high reading achievement scores was statistically significant, F (5, 348) = 9.687, $p < .001$. The R value was .350, which according to Cohen (1988) is a medium to typical effect size in the social sciences. The adjusted R^2 was .110. This indicates that 11% of the variance in reading achievement can be explained by the model. Doing homework was the only significant predictor ($p < .001$) of high reading achievement. Although the other four variables did not significantly contribute to the model, removing any one of them caused a slight decrease in the R value of the resulting model, leading the researcher to conclude that this is the most efficient model for predicting high student reading achievement that could be generated with this data set. The Pearson correlation between homework alone and reading achievement was r = .339, so the inclusion of the four additional predictors together contribute .011 to the R-value of .350 produced by the simultaneous multiple regression. Using the laptops for homework was by far the most significant predictor of high reading achievement scores, but the other factors did contribute somewhat to the model and none of the activities included in this model showed a negative correlation or a negative association with reading achievement, while most of the other independent variables in the data set did.

Qualitative Findings

In order to gain further insight into the perceptions of teachers regarding both the opportunities and benefits as well as the barriers and drawbacks in the use of the laptop computers for teaching and learning, and to develop a better understanding of the ways in which laptops are being used for instruction and learning at the school, three qualitative interviews were conducted after the quantitative analysis was complete. A purposive sampling method was used in which one teacher who self-identified as a frequent user of the laptops in the classroom, one teacher who self-identified as a formerly infrequent user who was using the laptops on an increasingly frequent basis, and a third who self-identified as an infrequent user of the laptops in the classroom were recruited. In addition, the final three participants were selected in order to provide a range of educators from different departments who teach at different levels. The sample was designed to include teachers of students from each of the four grade levels 9 – 12, and to include teachers of students in advanced, regular, and below grade-level classes.

The interviews were conducted and fully transcribed by the researcher. Analysis was conducted using the constant comparative method of qualitative analysis described by Boeije (2002). This method requires that the researcher develop a step-by-step plan for developing the analysis and to report her or his experiences when implementing the step by step approach (Boeije, 2002). The researcher developed a four step approach including:

1. Comparison within each interview.
2. Comparison between the interviews.
3. Comparison to the findings in the review of literature.
4. Comparison to the quantitative findings of this study.

Within each interview comparisons (step 1) were made using the process of open coding, through which every passage was studied and each passage was labeled with a code. When other passages were identified which conveyed the same or similar information, they were given the same code. When new information was presented, it was given a different code. After the entire coding process was complete, some codes were combined and others were eliminated, and some items were re-coded. The researcher continued the process until all passages in the interviews were coded and no sections were double-coded. Between interview comparisons (step 2) were then conducted using the process of axial coding through which central concepts were identified and defined and clusters of codes were discovered. These clusters represented patterns or combinations of codes, enabling the researcher to identify areas of comparison and contrast between the interviews. Codes which were not included in any of the clusters were then discarded and those passages were not included in the findings. This process resulted in the discovery of six clusters of codes, or themes: Ability level and homework, solutions for the lack of access at home, barriers and drawbacks, opportunities and benefits, perseverance, and professional development. Comparison of the findings with the findings of the review of literature (step 3), was also conducted in Chapter 5 in order to make connections between this study and the body of knowledge within this field and situate the findings of the present study within the existing body of literature as the basis for the generation of conclusions regarding the effects of the laptop program on the school and its students and teachers. The final comparison, to the quantitative findings (step 4) was then conducted in order to achieve triangulation of the qualitative data with the quantitative data generated through the student surveys and statistical analyses, and those conclusions are also reported in Chapter 5.

Identifying information has been removed from quotations when necessary in order to protect the identity of participants, including the names of particular classes and certain software programs, and pronoun choices should not be considered an indicator of the interviewees' self-identified gender. Teachers are identified by a number only, which was assigned randomly by the researcher.

Ability Level and Homework

Students at the school are placed into sections according to ability level in core curriculum classes. All three interviews indicated that ability level of the students was an important factor in the use of the laptops for learning both in and outside of the classroom. All three teachers indicated that they were more likely to assign homework which required the use of the laptops in advanced classes than below-grade-level courses.

Teacher 1 described her patterns of usage of a computer application which was used by students to complete assignments for her classes on their district-provided laptop computers. "In [an advanced course] once a week we do that as homework, but in our [below-grade-level course], we use it maybe a little less frequently, maybe at least once a month. It's the same type of online program, but it's not a homework a ssignment so they would never need to do it for homework, it's an in-class activity." This indicates that the ability level of students is a factor in the usage of laptops for learning in Teacher 1's class, and that advanced students are more likely to be given homework on their laptops than below grade-level students in teacher 1's classes.

A similar policy was described by Teacher 2, who indicated that he is less likely to assign homework which requires the use of the laptops in his below-grade-level courses. "Oftentimes the population that I find in front of me [in below-grade-level courses] lacks resources at home including Internet access. So, knowing that, I tend to shy away from assigning homework that does require Internet access." He expressed that in another course, which was not specifically for below-grade-level students, he was more likely to assign homework that required the use of the laptops:

> I often assign them [students in a regular class] work that does require them to get online. I do that pretty regularly, probably three out of the four days a week. And they are, almost without exception, or at least without technology issue exception, they are successful at it. I mean, certainly kids don't do homework for other reasons, but it's never the technology that stands in their way.

This indicates that Teacher 2, like Teacher 1, uses ability level as a factor in assigning homework to students and is less likely to assign homework which requires the use of the laptop computer to below grade level students than other students.

Teacher 3 indicated a similar reluctance to assign the use of the laptops for homework in her below-grade-level courses. "In my lower level classes students didn't have access to Wi-Fi at home, so I didn't use them much at all." She further expressed her concern about the potential impact on students who didn't have access to Wi-Fi at home, and how it influenced her decision not to assign homework requiring the laptops to below grade level students. "In my [below-grade-level class], the population that I think we are trying to bridge the digital divide for, there has been the least participation." This indicates a similar position to that of teachers 1 and 2 regarding the assignment of homework requiring laptops to students in below-grade-level reading courses and also expresses concern about how that might negatively impact the potential benefits of the one-to-one laptop program for students in those classes.

Solutions for the Lack of Access at Home

Both Teacher 2 and Teacher 3 indicated that access to the Internet at home was a significant issue for students' use of the laptop computers for learning purposes. In addition to the concerns described above, regarding the reluctance to assign homework to populations of students who are perceived to be less likely to have in home Wi-Fi access, two teachers discussed potential solutions to the problem. However, there were significant differences between the approaches that they took when discussing potential solutions. Teacher 2 tended to focus more on the things teachers and students could do to work around the problem of a lack of Internet access at home, while teacher 3 took a more systems and policies-level approach to proposing a solution to the problem.

Teacher 2 described one of the ways he has found to get around the problem of some students not having Internet access at home:

> I do use things that can be accessed in the classroom with our district's Internet and then convert it to a document that can be worked on at home, because I guess the beauty of the students having the laptops is, Internet or not, if they can access the material here at school and then download it or save it, then they don't need to access the Internet to find it and work on it later. It's been pretty successful.

This shows that Teacher 2 has created assignments that can be completed at home by students without access to the Internet through the use of downloading and saving processes which can be completed in the building on the district-provided Wi-Fi system. He also emphasized that there are other ways in which students can work around the lack of access even when they need the Internet to complete an assignment. "With my freshmen, when we do assign work for homework, we also understand that they have opportunities in the building to access the wireless and the Internet and do their work here, including a [study hall] class where they'll have an opportunity to work on homework. Or during their lunch period slash off period, they might have an opportunity to go the library/LTC and work." This indicates Teacher 2's belief that students can use the district provided Wi-Fi access and complete their laptop-dependent homework at school, another example of the ways that students might be able to work around the issue of Internet access at home.

Teacher 3 expressed a social justice oriented perspective on the issue of the lack of Internet access at home. She advocated for assistance for those families who lack Wi-Fi access. "A lot of my students who are babysitting really young kids, they can't get all of them on the bus to go to the library where the Wi-Fi is. I wish that we were using our funds to give Wi-Fi to families who need it. If we are going to close this gap, truly bridge that gap." She went on to describe the effect that a lack of access at home has had on some of her students:

> Most of the time they fly under the radar, because they don't want their peers to hear that. It is humiliating and embarrassing for them. But I develop close relationships with them and then later, and this is usually after they have already accumulated a lot of missing assignments, weeks in, after we have built a really good relationship, they will confide in me that they don't have access to [Wi-Fi at home], and they don't have time to get to it at home. And a lot of teachers are assuming that they can do that and they can't.

This reveals the belief that a lack of Wi-Fi access at home is a serious problem for some students, both academically and socially, and that those students are at a disadvantage compared to students with access. It also expresses a perception that some teachers in the building do not recognize the problems facing students without access to Wi-Fi at home, a point which she expanded on later. “The teachers, I know they don’t. Because I got into an argument with [a colleague at the school] saying, ‘You’re assuming kids have access to this and they don’t. And there isn’t an opportunity to turn in these assignments. That’s just not OK.’ So I think a lot of teachers have no clue that’s going on.” This expresses Teacher 3’s perception that some teachers at the school are not recognizing the difficulty certain students have in completing Internet dependent homework due to a lack of access to reliable Wi-Fi, and that attitude is negatively impacting the academic success of those students. Taken together, these quotations reveal the social justice perspective of Teacher 3 and express her desire both for funding to provide access to the Internet for all students, as well as more awareness on the part of teachers regarding the impact a lack of in home Wi-Fi access may be having on students in their classrooms.

Barriers and Drawbacks

The interviews revealed some concerns about the use of laptops for learning. There were four main categories of barriers to and/or drawbacks from using the laptop computers for learning purposes: Software and hardware availability, the waste of class time, students not bringing the laptops to class, and teachers’ reluctance to use the laptops.

Software and hardware availability. Two teachers reported that the availability of software and hardware has been a barrier to the use of laptops in their classes. Teacher 1 reported that software availability was a barrier to the use of the laptops to promote student preparation for the state standardized test, called the PARCC Assessment. She described a program which had formerly been in the public domain but which now required an expensive membership. “Actually, I’m at a loss right now because the web site, I’ve used it for the last five years, and the web site this year just got pulled. So now it says we're not offering this anymore. So now I'm not sure what I'm going to do." This shows how the availability of software, which can be uncertain from year to year, can create a barrier for teachers. She went on to explain how the disappearance of this valuable program from the public domain was going to create a barrier for her use of the laptops moving forward. "I do think for PARCC training it was really good, but now that this website is gone, I just don't know what I'm going to do. At all."

Teacher 3 reported a similar barrier to the effective use of the laptops, but her problem was related to the Wi-Fi hardware which was initially installed in the school. "The other reason that I didn't use them is because there was a dead spot. Classrooms on either side could access it, but we couldn't where I was. They had to fix all the Wi-Fi. They had to upgrade it in the hallway with new hubs. The first year they didn't have that, the second year they didn't have that, so really this is the first year that there is seamless access." This shows that hardware issues were a barrier to Teacher 3 in using the laptops for learning purposes in her classroom before the school's Wi-Fi capability was upgraded.

Waste of class time. All three teachers expressed concerns about how the laptops can have a negative impact on their use of instructional time. Teacher 3 described how technical difficulties could cause her to lose almost an entire day of instructional time. "I would create tests and students wouldn't be able to take them. I would create lessons and they wouldn't be able to get to them and we would spend most of the forty-five minutes just trying to get them to load, so it was a huge waste of time." And teacher 1 expressed similar concerns, arguing that the potential waste of instructional time has had a negative impact on the frequency of laptop use for instructional purposes. "Not everybody has been as open-minded to [the use of the laptops]. Because it's a time issue, those days are very hectic." This reveals a shared concern about how the laptops can be a potential waste of classroom time, and the perception that this is an important barrier to the use of laptops in the classroom.

Teacher 2 shared similar concerns about the potential waste of time that laptops can present, but also indicated that after working over a period of time to establish strong routines with his students, and after becoming more comfortable with the laptops himself, now they actually save instructional time. "At first I was like, 'They're just going to get on there and they're going to get on YouTube and they're going to find games and they're going to play, and we aren't going to be able to get them to focus on what we are trying to teach here in the classroom.'" This shows that during the initial phase of the laptop program Teacher 2 had concerns about the potential waste of classroom time they presented. However, he indicated that now, five years after the initial implementation, his perspective has changed dramatically. "I would say 80 – 90 percent of my kids when I walk into the room as the bell is ringing, they are taking out their laptops or they have them out, they are opened and they are accessing the appropriate materials for class, and it has saved a ton of time. What started out as my fears of the laptops being a time waster has actually flip-flopped, and saved me a lot of time." This shows that for Teacher 2, the use of the laptops has become more efficient over time and that his initial fears that they would be a time waster have changed to a belief that the laptops save instructional time when used effectively.

Students not bringing laptops to class. All three teachers described their experience that students failing to bring the laptops to class was a significant barrier to their effective use in the classroom. The students have 24-hour access to the laptops, which means that they have to remember to bring them home, keep them charged properly, and bring them back to class each day. Teacher 1 brought up this issue immediately when asked about potential barriers to the use of laptops in her classroom. “First off, and this is more for the lower level versus upper level [classes], everybody having them and that they’re charged. That is a barrier, and that’s a huge barrier.” Teacher 2 expressed a similar sentiment, arguing that students bringing their laptops and having them properly charged was an important prerequisite to the effective use of the laptops in his classroom. “Now everybody has a laptop, so if they come with it charged and, well, in their possession, things run really smoothly.” Teacher 3 listed multiple reasons that students might not bring their laptops to class when discussing the barriers to their use she has experienced in her classroom. “Over half of my class, sections of my class, didn’t have laptops because they were taken away for behavior concerns or they couldn’t afford the deposit so they couldn’t get them. Or if they did have them, they were broken.” However, she also observed that more recently, as the program has developed, more students are bringing the laptops to class and she has been able to largely work around this problem because three desktop computers have been placed in her classroom for student use. “Now, I have in those same classes about 90 percent who have laptops, who have completed the protocol, and I can supplement with three computers in the back of the room, so I will be using them every day now.” This shows that for Teacher 3, increased student participation in the program, along with supplemental computers placed in her classroom, has helped her to overcome the initial problem of students not bringing their laptops to class.

Teachers’ reluctance to use the laptops. All three interviews provided evidence of a reluctance on the part of some teachers at the school to use the laptops for classroom instruction. Two of the interviews revealed the shared perception that other teachers at the school have negative perceptions toward the use of the laptops which impact the frequency of their use for instructional purposes. In addition, all three teachers indicated that at times they themselves have felt a reluctance to use the laptops for various reasons including their specific content-area, the grade and ability level of their students, and the confusing nature of technology.

Content area concerns. When asked how often she uses the laptops, Teacher 1 indicated that she does use them sometimes, but quickly added that she does not believe that many other teachers in her department use them as often as she does. "At least once a week. Not never. That's in my classroom, but other people in my department would probably answer never. I use them more than most." This indicates her perception that math teachers in general are less likely to use the laptops than other teachers. She went on to explain the specific issues that math teachers face which could explain this phenomenon. "It's very difficult to type all the symbols and the powers and the negatives and it's hard to show your work. So, that's why the majority of the math department doesn't use laptops." She communicated her belief that the laptops are more effective in other curriculum areas than they are in math. "It is a lot easier to do [math] with paper and pencil. In English I see, typing is faster, but in math typing is significantly not faster, and so there's some resistance there. We don't use them a lot. We kind of have to go out of our way to find ways to use them." This reveals a department-specific barrier to the use of the laptops, an inherent characteristic of math studies in particular, which is a formidable barrier to the use of the laptops for learning in that department which Teacher 1 believes can explain math teachers' reluctance to use them.

Grade and ability level. Teacher 2 indicated that the grade and ability level of the students is a factor in some teachers' reluctance to the use the laptops for instructional purposes. "That is something I've thought a lot about and I've tried to encourage some of my colleagues to consider as well, because within the context of low-level readers and kids who aren't proficient at playing school, these ninth graders, oftentimes colleagues of mine who taught these same students were very reluctant to use laptops, and I was honestly at first too." This reveals a belief that ability and grade level plays a factor in some teachers' reluctance to use the laptops in some classes, a feeling which this teacher shared early on in the laptop program. He went on to describe a more specific example of this phenomenon. "Based on my observations and conversations with [another classroom teacher at the school], she shies away from using them. And I have been pushing her a little bit to use them more and she has talked about wanting to use them more, but she is one that I know is very reluctant to use them." This provides a specific example in which the teacher describes a colleague who is somewhat reluctant to integrate the laptops into her classroom.

Confusing nature of technology. One other factor which was identified which could explain the reluctance of some teachers to use the laptops is the complicated nature of technology. This is seen in the difficulties Teacher 3 expressed in finding ways to use the laptops effectively. "It gets too confusing for me, managing all the technology. I spent a month of my summer setting up my Google classroom, and I just, still, now in its application process, I don't really clearly understand." She explained that despite her efforts to find professional development opportunities, she still feels that technical understanding has been a factor in her sometime reluctance to use the laptops in her classroom. "There are fifteen apps loaded into google classroom, and they sound really cool, and they look like they will be really great for the students to help them engage and get really interested in the learning, but I don't know how they're actually going to work, so we'll see." Later in the interview she came back to this subject. "I just look at all the training I've had, and how I use it at work every day, and it still is confusing to me because my kids are ahead of me on the curve." This last statement also expresses a perception that the teenagers in her classes can be more adept at using the technology than the teacher is, which may also contribute to her reluctance to use the laptops in her classroom.

Opportunities and Benefits

All three teachers identified benefits and opportunities for the promotion of student learning which they had observed as a result of the laptop program. There were three main categories opportunities and benefits of the laptop program: Standardized test preparation, preparation for the future, and organizational benefits.

Standardized test preparation. The state PARCC test is now administered on computer, rather than the traditional pencil and paper format of years past. This means that the laptops can play an important role in preparing students for standardized tests. Teacher 1 described the importance of a laptop software program in preparing students for the yearly state exam in her content area. “I think that’s why students have a hard time on the new online PARCC tests as well, because they’ve never had to type math before. And so that’s why I started introducing [the software program] in my classrooms. It’s mainly for those PARCC tests.” She went on to describe the similarities between the program she used and the format of the standardized test. “It has the same set up as the PARCC test, so it’s basically a PARCC practice. So literally, it has the same format boxes, it looks the same, so it’s a good practice for them.” She expressed concern about the fact that math test scores had dropped after the adoption of the online standardized testing format, and expressed her belief that the new format was a barrier to student success. “It’s just not user friendly, and I think that is a reason why sometimes students don’t try super hard on some of those online tests, because it’s too hard of a setup.” This shows how the laptops can play an important role in preparing students for the state tests, particularly in light of the recent change from a paper and pencil format to a computer-based testing format.

Preparation for the future. Two of the teachers indicated that they felt the laptops played an important role in preparing students for their futures, in which they are likely to encounter computers in college or in their workplaces. Teacher 1 indicated that she felt that the laptop program played an important role in preparing students for their college level studies, particularly the use of computers for the completion of math homework at the college level. "I've been [using a software application] and it's really helped because in a lot of the college level math classes, that's how they do homework. At the college level they have to type it into a program. So we are practicing for the types of programs they will see in their college level math classes." This conveys the belief that students who have the benefit of the one-to-one laptop experience may be better prepared for the requirements they will be expected to meet in their college level coursework.

Teacher 3 also stated that she felt the laptops were important in preparing students for their futures. She expressed the importance of learning how to use technology in preparing students for the work force and reiterated her concerns about the potential effect a lack of access to the Internet at home could play in failing to reduce the digital divide. "Tech is important. And knowing how to use tech is important for the kids so they have some kind of knowledge when using it in their jobs." Although she expressed hopefulness that the one-to-one program could provide valuable technology skills to all of her students, she also re-iterated her concern that not all students are benefiting equally and that something should be done to help students without Wi-Fi access at home. "I do feel we have got to supplement somehow for those families if we are truly going to bridge the digital divide."

Organizational benefits. Two teachers reported that the laptops improve students' organization, which can be beneficial to their academic success. Teacher 2 said that students in his below grade-level courses experienced clear benefits in finding assignments and other classwork that might otherwise have been lost:

> I deal with low-level readers who often come with many other, um, educational deficiencies. They have found for example, the use of Google Classroom and Google Drive to be a lifesaver as far as organization goes, because it almost organizes things for them. So they are able to find things way more quickly and we are able to save a lot more time in class.

Google Classroom is a suite of productivity tools for classroom collaboration, that is free to the teachers and students at the school, which students and teachers can access on their laptops by logging in with their district email accounts. This shows how Teacher 2's students have benefited organizationally from the use of the laptop computers, particularly students who may not have strong organization skills and for whom keeping classwork organized could otherwise become a barrier to success.

Teacher 3 expressed her belief that the laptops have helped keep her and her students more organized:

> I also use Blackboard. There are many things I really like about Blackboard. I like having it clearly set up by units. I think it's difficult for kids who have organizational issues, but on Blackboard, they can click on it more clearly and its easier for me to add something that I've worked on or heard about on NPR into a unit that already exists.

Blackboard, a popular e-Education platform which is paid for and made available to teachers and students at the school by the school district, enables teachers to post classroom materials and students to submit work online using their laptop computers. This shows that while Teacher 3 uses Google Classroom, and Teacher 2 uses Blackboard, both teachers have found that the use of the laptops to access online platforms for learning can benefit students organizationally and help students who struggle with organization to keep track of their class work and find class resources.

Perseverance

Both the teacher who reported using the laptop computers on a daily basis, and the teacher who reported increasing levels of usage over the last three years, communicated the need for perseverance in order to effectively integrate the laptops into the learning process. There can be significant barriers to using the laptops, as outlined above, and both teachers stressed the importance of making a continual effort to integrate the laptops effectively in order to overcome the barriers to their use.

Teacher 2 indicated that in the early days of the laptop program he ran into some significant barriers to the use of the laptops, but he persisted in using them and found ways to make them successful:

> I quickly reflected and thought, you know, I need to give them a chance and that chance needs to not be a one-time chance, it needs to be one chance, two chances, three chances, four chances, and really persevere with the regular use of the laptops with these kids. My lack of experience combined with their lack of experience combined with a shiny new machine looked like a recipe for off-task disastrous classroom sessions, but it ended up being another opportunity to kind of teach that perseverance piece, for myself and my

> students. If it's not going well, it would be really easy to eject and say, "OK we're going to go to the paper copy" or "We're going to go to the backup plan." But living in that realm of discomfort and chaos at times paid off, because once we were able to face those challenges and work our way through them together as a classroom community, it paid huge dividends.

This shows both the importance of perseverance on the part of students and the teacher in developing ways to efficiently incorporate the laptops into the learning process, and also indicates Teacher 2's belief that his perseverance ultimately resulted in substantial benefits to the learning process.

Teacher 3 reported that finding ways to integrate the laptops effectively is an ongoing process and that overcoming her initial difficulties in integrating laptops into her daily instructional practices required not only perseverance on her part, but also outside support. "I still don't understand [a software application] well enough to really implement it, and so [a tech support worker at the district] is going to be coming in with me on Friday to help me with that. And I've set up monthly sessions where she is going to come in once a month to help me out." This shows that the use of the laptops as part of classroom instruction took time for her to implement, and still requires technical support. She also expressed her belief that her perseverance in finding ways to use the laptops was beginning to show positive results. "At first not very much, but now it's been three years that we've been using them and I think now it is starting to be more effective."

Professional Development

Both the teacher who reported using the laptops on a daily basis and the teacher who reported that she had increased her usage over the last three years reported that they had participated in professional development opportunities provided by the district outside of the initial four-day laptop training which was required by the district in the first year of the one-to-one laptop program. The teacher who reported lower levels of laptop usage in the classroom, however, did not report having attended any additional training, and didn't find the initial training to be applicable to her content area.

Teacher 1 reported that although she has explored the use of specific programs for her classes on her own, she has not taken any additional formal professional development training classes since the initial laptop implementation. "I did the laptop training when we had to; the one we had to do. And then other than that I've done some program trainings for myself, but I've never taken any classes that are like, 'how to use a laptop in math' or something." She also expressed the perception that the initial training was not helpful for math teachers compared with the usefulness she perceived for teachers in other content areas. "I didn't find it super helpful. I think for social studies, language arts, research classes, sure. But we don't do a ton of that in math. I mean yes, we can do a research paper, but it's not like we do that on a regular basis. So as for the constant use of it in class … we just don't." This shows that the professional development program offered by the district was not seen as particularly relevant to the unique conditions of math instruction in particular, and that Teacher 1 believes that there are inherent differences in the processes of teaching and learning in math which make the laptop professional development courses less relevant to math than other content areas.

In contrast Teacher 2, who reported consistent daily use of the laptops for instruction, indicated that he had taken numerous professional development training classes, and found them to be mostly relevant to his instructional practices:

> I have taken several courses. As district staff when the laptops were rolled out we were required to take a four-day training during which we were introduced to the laptops as well as a way of designing lessons. The half that dealt with how to design lessons was not technology specific, it was more just kind of "good teaching," and I felt that was unnecessary or out of the context of the use of laptops. But there was a section of that training that was concrete and applicable to the use of the laptops and helping the students use them, so it was beneficial but I felt like it could have been reduced. I have also taken Smart Board training which was not specific to the laptops but helped me use another technological tool in the classroom, which definitely helped and helped me understand how to use the software associated with it as well as the hardware. And just last year I took part in a seven-hour professional development course. It was structured pretty loosely and was designed more to allow the participants, there were about ten or twelve of us teachers, to play with some of the add-ons and features that Google provides. So the opportunity to have dedicated time to play around with features certainly helped and I was able to take maybe two or three of the applications or add-ons and use them regularly in the classroom. But honestly the way the class was structured loosely and felt somewhat unplanned, I felt wasted some time, but I thought it was a good opportunity and I commend the district for offering opportunities, and they continue to offer opportunities.

This shows that Teacher 2 has sought out professional development opportunities beyond the required training, and that he believes that those trainings were beneficial in helping to integrate the laptops in daily classroom instruction. It also indicates some concerns about how the professional development classes are organized, and the applicability of all aspects of those classes to the use of the laptops. Overall, however, it indicates that this teacher is appreciative of the opportunities for professional development provided by the district and believes that they have helped him to integrate the laptops into the daily learning process of his students.

Teacher 3, who reported increasing levels of laptop usage over the last three years, emphasized the role that professional development has played in that process. "I've done, gosh, when the laptops came out and the Smart Boards came out, I did all of that required training. And even though I'm at the top of the pay scale and I don't need any lane changes, I'm continuing to do training."   She stated that even with effective professional development trainings, the process of implementing the actual usage of the laptops for learning can still be a struggle:

> I did four weeks of training this summer on Google Classroom, and still, now in its application process, I don't really clearly understand. There are fifteen apps loaded into Google Classroom, and they sound really cool, and they look like they will be really great for the students to help them engage and get really interested in learning, but I don't know how they're actually going to work, so we'll see.

This connects to the previous section's findings and the expressed need for perseverance in the effective adoption of the laptop program by this teacher. It indicates that the training was an important part of finding ways to effectively integrate laptops into instructional practices, but that the process of applying those ideas in the classroom was still a challenge.

Summary of Findings

This study found that 88 percent of the students in the sample population have reliable Internet access at home, and that students report frequently using their laptops for a variety of different activities, not all of them school related. Doing homework and outside the classroom learning were the most frequently reported uses of the laptops, while watching videos was the most common non-academic activity reported. Students also frequently used their laptops for playing games, social networking, and contributing to online databases. Students reported using their laptops in their language arts classes the most frequently, and the least frequently in math. Using the laptops for homework, outside the classroom learning, and accessing math resources were significantly correlated with high reading achievement, while contributing to online databases, collaborating with peers from a different school, reading about people/bands/actors/artists, writing blogs, posts or comments, social networking of all kinds (with experts, celebrities, friends, and family), reading sports news, and playing multi-player games were all significantly correlated with low reading achievement. 15% of the variance in low reading achievement among participating students could be predicted by a statistical model using the independent variables contributing to online databases, watching videos, writing blogs, comments, or posts, social networking, playing games, and analyzing data. 11% of the variance in high reading achievement among participating students could be predicted by a statistical model using the independent variables doing homework, reading political news, reading messages, collaborating with same-school peers, and accessing math resources.

Constant comparative analysis of the qualitative interviews of classroom teachers revealed six themes: Ability level and homework, solutions for the lack of access at home, barriers and drawbacks, opportunities and benefits, perseverance, and professional development.

All three teachers reported that they were less likely to assign homework which required the laptops to their below-grade-level classes than their grade-level or advanced classes, and two teachers specifically mentioned that concerns about students' access to Wi-Fi at home was a factor in that decision. Two teachers discussed potential solutions for the problem of students not having access to Wi-Fi connectivity at home. One teacher focused on teacher and student-level solutions to the problem, including giving students work which could be downloaded using the school's Wi-Fi onto the laptops and then completed at home even if the Internet was not available. Another teacher argued for systemic solutions to the problem, including funding for families that don't have Wi-Fi and increased awareness among teachers regarding the problems facing students without reliable Internet access at home.

The interviews revealed four specific barriers to or drawbacks from the use of the laptops for classroom instruction: software and hardware availability, the waste of class time, students not bringing their laptops to class, and teachers' reluctance to use the laptops. One teacher reported that the disappearance of a software program had been a barrier to the use of laptops to promote student achievement, and another reported that hardware issues related to the availability of Wi-Fi in the building had been a barrier to the use of the laptops in her class. All three teachers reported concerns that the laptops could waste valuable class time, although one teacher reported that after developing classroom routines over time he found that the initial loss of time reversed itself and he now finds that the laptops actually save class time. All three teachers reported that students failing to bring their laptops to class was a barrier to their use, although one teacher reported that the installation of three desktop computers for student use in her classroom had helped to alleviate this problem. The final barrier to the use of the laptops was a reported reluctance among some teachers to use the laptops in their classes. One teacher reported that the laptops were not efficient for the completion of math work, another reported a reluctance on the part of colleagues to use the computers with young (ninth grade) students, or with below-grade-level students, and the third reported that the confusing nature of the technology had been a barrier to the integration of the laptops into her classroom instruction.

There were three major opportunities to and benefits from the use of the laptops reported by the teachers. One teacher reported that the laptops helped prepare students for online standardized tests. Two teachers indicated their belief that the laptops were valuable in preparing students for their future; one specifically mentioned preparation for college and another mentioned preparation for the work world. In addition, two of the teachers said that there were organizational benefits for the students, particularly students with low organizational skills.

Both of the teachers who reported frequently using the laptops also reported the need for perseverance. One teacher indicated that he and his students had persevered when faced with challenges and barriers to the use of the laptops, but over time he had overcome those challenges through perseverance. He indicated that he believed that the effort to use the laptops had ultimately been beneficial. Another teacher shared that she had faced significant barriers to the use of the laptops initially, but had persevered and was now using the laptops every day in her classroom. Both of the teachers who reported high levels of usage of the laptops also reported having undergone significant amounts of technology-specific professional development training. The highest-frequency user of the laptops reported ongoing training and professional development, and expressed appreciation for those opportunities and indicated that they helped him find ways to use the laptops in his classroom. Another teacher indicated that she had initially been slow to adopt the laptops in her classroom, but said that she had pursued a four-week professional development course which had helped her to integrate the laptops more effectively. She also indicated that she needed additional tech support during the actual implementation process, as she applied what she had learned to the teaching environment.

CHAPTER FIVE: DISCUSSION

The goal of this study, as stated in the research questions, was to examine the ways in which different types and frequencies of laptop usage relate to student reading achievement, and also to investigate the factors which have enabled teachers to adopt the laptops into their instruction, or prevented them from doing so effectively. Based on the quantitative and qualitative data collected and reported in chapter four, some observations are made and some conclusions are drawn on which some recommendations for future practice are based.

Study Summary

For today's students and teachers, technology has become an essential and ubiquitous part of everyday life (Fleischer, 2012; Gorder, 2007; Jett, 2013; Niles, 2006). The rise of technologies' influence in our daily lives has driven the desire to integrate technology into our classrooms in order to promote technological literacy, which will enable students to effectively compete and participate in the twenty-first century workforce (Friedman, 2007). Over the course of the last decade we have seen a fundamentally transformative increase in the presence of one-to-one computer technology in our schools. In 2006 24% of school districts had or were implementing a one-to-one technology program (Abell, 2008; Borja, 2006). By 2010 that number had increased to 37% (Nagel, 2010) and by 2015 more than half of students and teachers were using a school-provided personal computer (Molnar, 2015). This rapid growth has generated a need for up-to-date research regarding the impact of such programs on student achievement, and a closer examination of the barriers and opportunities which impact the use of laptops for learning in one-to-one environments.

Need for the Study

A recent review of the existing research on one-to-one laptop programs and student achievement revealed that although the existing data is promising, it is far from painting a complete picture of the effects of such programs on student achievement (Zheng et al., 2016). There is a still a need for more empirical data regarding the relationship between such programs and student learning (Storz & Hoffman, 2013; Suhr, Hernandez, Grimes, & Warschauer, 2010). Mixed results in previous studies have shown that the mere presence of the technology itself will not necessarily impact student learning or achievement, the key lies in how the technology is used (Bryan, 2011; Goodwin, 2011; Harris, 2010; Hoyer, 2011; Silvernail & University of Southern Maine, 2005; Ware & Warschauer, 2005). Types and frequency of laptop usage vary widely from student to student and teacher to teacher within one-to-one laptop programs (Boardman, 2012; Goodwin, 2011; Jones, 2013; Spires et al., 2012; Storz & Hoffman, 2013; Weber, 2012), making it difficult to ascertain the relationship between actual usage and student achievement by looking at overall changes in achievement levels among entire populations of students. However, emerging evidence indicates that measurements which take such variations in behavior into account can give us a clearer picture of that relationship (Abell Foundation, 2008; Kay, 2010; Shapley et al., 2010; Spires, Oliver, & Corn, 2012; Weber, 2012; Zheng et al., 2016). Therefore, this study was designed to meet the need for the further development of our understanding of the relationship between one-to-one laptop programs and student achievement by exploring associations between individually reported types and frequencies of laptop computer use and individual student reading achievement scores.

Method

This was a mixed-methods study which used quantitative research methods in order to measure associations between student laptop usage and student reading achievement scores. It also used qualitative methods in order to seek a better understanding of teacher attitudes and perceptions of the laptop program and the barriers and opportunities they perceive in integrating the laptop computers into the teaching and learning process. Laptop usage surveys were administered to 366 students at a suburban high school, the results of that survey were compared with student scores on the MAP reading achievement test using correlation and regression statistics, and those results were reported quantitatively. In addition, four teachers from a variety of content areas and grade levels were interviewed and those results were reported qualitatively. Conclusions and recommendations were drawn from a synthesis of the quantitative and qualitative information, with the findings of each supporting and informing the researcher's analysis of the other. This type of convergence can increase the validity of inferences and conclusions (Lund, 2012), and combine the most powerful elements of qualitative and quantitative methods together (Creswell, 2008).

Research Questions

This study was designed to answer four main questions. The first two questions are related to the relationship between student usage of the laptops and reading achievement scores. They were answered using primarily quantitative methods. The second two are related to the barriers and opportunities for integrating the laptops into the learning process perceived by teachers. They were answered primarily using qualitative methods. The research questions which guided this study were:

1. Is there a relationship between the frequency of reported laptop use by students and their reading achievement as measured by the MAP reading test?
2. Is there a relationship between the reported ways in which students use their laptops and their reading achievement as measured by the MAP reading test?
3. What resources and skills have enabled teachers to incorporate the laptops into their classroom activities and instruction?
4. What barriers and obstacles have discouraged or limited teachers' incorporation of the laptops into their classroom activities and instruction?

Discussion of Findings

This study found that students in the one-to-one laptop program used their laptops frequently and for a variety of purposes. It found statistically significant positive correlations between student reading achievement and the use of the laptop computers for doing homework and learning outside the classroom. It found statistically significant negative correlations between reading achievement and the use of the laptops for activities like playing games, social networking, and contributing to online databases. Statistical models were developed which predict high and low reading achievement scores at a statistically significant level based on student type and frequency of laptop usage. Additional findings and associated conclusions are discussed in more detail below.

Types and Frequencies of Laptop Usage

This study was conducted in a school which was in the fifth year of its laptop program. Participating students had been provided their laptops full-time in the sixth grade, which means that they had been using their district-provided laptops in the school setting for four years (in the case of 9^{th} graders) or five years (for 10^{th} graders). Likewise, their teachers have had sufficient time to fully adopt and implement the laptop program and incorporate the laptops into their classroom instruction and homework assignments. This meets the need, identified by Storz and Hoffman (2013), for studies of mature laptop initiatives that have had sufficient time to be fully implemented.

The vast majority of students indicated that they had access to the Internet at home, which means that the majority of students in the sample population are very likely to have access to one or more computers other than the district-provided laptop. However, for the 2.5% of students who indicated that they do not have access to the Internet at home, and for the 9% who indicated that their access at home is slow or unreliable, it is possible that the district-provided laptop is the only reliable computer that they have personal access to. It is also possible that in homes with Internet access there could still be limited access to computers based on the number of individuals in the household compared to the number of available computers. Based on the rates of reported usage of the laptops it seems that despite high levels of access to the Internet at home, the laptops are still very useful for students in the sample population for a variety of different activities, including doing homework. There was no statistically significant difference in the rates of usage of the laptops for homework between students who have reliable Internet access at home and those who do not. This indicates that a lack of reliable Internet connectivity in the home does not appear to be a significant barrier to the use of the computers for homework assignments. This appears to support the claim of Harris (2010) that one-to-one laptop programs can help close the digital divide and provide access to computers for learning purposes to all students.

It is clear based on the survey data collected that participating students used their laptops the most frequently in language arts and social studies class, and the least frequently in math class. This finding corresponds with the findings of Zuber and Anderson (2013), whose study supported findings reported in their literature review, which showed that mathematics teachers are the least frequent users of one-to-one laptops, and the findings of Burgard (2008) which provided additional evidence showing that language arts and social studies teachers use laptops the most frequently, and math teachers the least. The in-class usage patterns of the sample population appear to correspond to expectations established in previous studies, and indicate a clear pattern of teacher usage of laptops for classroom instruction based on content area. It appears that with the exception of math classes, the laptops have become an integral part of classroom learning in the school.

It is also clear that many students are using the laptop computers outside the classroom in order to do homework and to engage in learning outside of the classroom. Only six percent of respondents indicated that they rarely or never use their laptops for homework, which shows that the students are overwhelmingly using the district provided laptops for learning purposes, and that the laptops have become an integral part of student learning activities at the school. Despite the fact that math teachers do not use the laptops in class, half of the respondents indicated that they have at least sometimes used their laptops outside of the classroom to access math resources, an activity which correlates with higher reading achievement. It may be that there is untapped potential for the more frequent use of the laptops in math instruction.

The laptops are being used for a number of non-academic purposes as well. Almost half of the survey respondents indicated that they watch videos online most days or every day, and 40 percent indicated that they play games at least sometimes despite attempts by the district to limit access to games. In addition, 30 percent indicated that they social network with friends at least sometimes, despite district-level blocks on social networking web sites. It is not immediately clear how these numbers relate to overall usage of computers by students for these types of activities, but it is clear that the district-provided laptop computers are being used for a variety of different purposes, not all of them school-related.

This generation of students is highly connected and has grown up in a world of ubiquitous computing which older generations did not experience (Niles, 2006). The laptop usage data indicates that students in the sample population have embraced the use of their district-provided laptop computers and use them frequently for a variety of different purposes. Developing computer skills is an important part of preparing students for their high-tech futures (Spires, Oliver, & Corn, 2012), but the purpose of this study was to assess the relationship between the use of the laptops and student reading achievement, which will be explored more fully in the next section.

Types of Use Correlated with High Reading Achievement

This study has produced compelling evidence that there is a correlation between the types and frequencies of student laptop usage and reading achievement. Because it focuses on reading achievement specifically, it meets the need for more research exploring the connection between laptop initiatives and student achievement described by Storz and Hoffman (2013) as well as Suhr, Hernandez, Grimes, and Warschauer (2010). As expected based on the review of literature (Goodwin, 2011), some teachers and some departments have more fully integrated the laptops than others, and students are using the laptops in many different ways. Because these findings are correlated with individual student's reported usage types and frequencies rather than district-wide or school-wide achievement levels, they also meet the need for new studies based on individual student usage in order to more clearly discern the relationship between laptop use and student achievement identified by Silvernail and University of Southern Maine (2005) as well as Spires, Oliver, and Corn (2012).

There were three independent variables which positively correlated with reading achievement at a statistically significant level. Correlation is not proof of causation, and these findings should not be generalized to indicate that there is a cause and effect relationship between any particular type of laptop usage and high or low reading achievement. However, there were significant positive correlations with three of the independent variables, and one of them was accessing math resources. This is an interesting finding both because math and reading are often considered discrete skills and because math classes were by far the least likely of all four content areas to incorporate the laptops into classroom instruction and learning. This finding indicates that the ability to find and access math help online is closely related to the ability to read and comprehend the kinds of complex materials that show up on the MAP reading test. It may be valuable for math teachers to explore ways of encouraging students to use laptops for learning purposes even in that traditionally low-usage content area.

The most beneficial use of the laptops in promoting student reading achievement appears to be in their use for doing homework. This supports the findings of Jett (2013), Kay (2010), and Shapley et al. (2010) which indicate that using the laptops at home is one of the best indicators of student achievement. Professional educators with specific learning targets in mind can design homework assignments which promote the development of reading skills, while other non-teacher-directed activities are not likely to promote strong reading skills and may actually harm the development of reading skills by distracting students from learning. It seems unlikely based on this data that simply giving high school students laptops to use in an undirected and unguided way will promote the development of strong reading skills. Technology alone is not the answer, but using technology in ways specifically designed by professional teachers to promote student achievement is.

Types of Use Correlated with Low Reading Achievement

Most types of laptop usage were negatively correlated with reading achievement. These include playing games, social networking, contributing to online databases, and reading about celebrities, bands, people, or sports. Therefore, if teachers, parents, students, and others are interested in improving reading achievement, these types of activities should possibly be curtailed or reduced, particularly when they compete with or take away from student learning opportunities.

Based on the correlation statistics it seems that even activities which involve significant amounts of online reading are not necessarily conducive to high reading achievement. Reading about sports, bands, or celebrities, or reading social networking posts, blogs, or other types of online content is negatively correlated with reading achievement. Some other types of reading, such as reading international or political news or reading messages, although not negatively correlated, was not significantly positive either. Even activities such as conducting research and analyzing information were not positively correlated with reading achievement, although it is not clear based on these findings what subjects or interests the students are researching and analyzing. This could mean that students are researching and analyzing things such as how to play an instrument, how to play certain games, or other subjects which might be conducive to learning things the students are interested in, but which are not likely to produce achievement gains on the MAP reading test. Although collaborative learning has been touted as a potentially positive indicator of student achievement (Goodwin, 2011) collaborating with peers from other schools was significantly negatively correlated with reading achievement. Collaborating with peers at the same school was not negatively correlated, but it was not positively correlated with high reading achievement at a statistically significant level either. Reading for specific academic purposes, as one does when doing homework, appears to be a much more significant indicator of high reading achievement than the kinds of generalized reading found most frequently on the Internet.

In-class Use of Laptops and Reading Achievement

One surprising finding was that the usage of laptops in social studies class was negatively correlated with reading achievement. No other statistically significant correlations between in-class use and reading achievement were identified. This indicates that the use of laptops for learning purposes does not appear to be positively correlated with high levels of student reading achievement, and in some cases may be negatively correlated with reading achievement. This may explain the mixed results of past studies in establishing a correlation between laptop programs and student reading achievement identified in the review of literature (e.g. Hoyer, 2011), and may also explain the lack of statistically significant correlations between laptop programs and reading achievement identified in the recent meta-analysis of laptop studies and student achievement (Zheng et al., 2016). The findings of this study appear to support the claim that the use of laptops for classroom learning, in and of itself, does not promote student reading achievement.

Predicting Low Reading Achievement

There were a large number of types of laptop usage which were negatively correlated with reading achievement. The students have had access to their district-provided laptops for four or five years, and the vast majority (97%) of them have at least some Internet access at home. Therefore, the ways in which they use computers are likely to have a strong relationship with their overall reading achievement, and this study supports that claim. Students who spend time contributing to online databases (participant-generated websites), watching videos, writing blogs, comments, or posts on web sites, social networking, playing games, and analyzing data are significantly more likely to have lower reading achievement. The combination of these activities contributed to 15% of students' overall reading achievement score, a practically as well as statistically significant effect. To the extent that these kinds of activities distract students from completing homework or learning in class, they are likely to be even more detrimental to student achievement.

Although computers can be powerful learning tools, it is clear that the types of usage are not at all equal. Parents, teachers, and others who have an interest in promoting strong reading skills should discourage or limit student participation in those types of activities online, particularly if they begin to interfere with the completion of homework.

Predicting High Reading Achievement

The only three types of laptop usage which were significantly correlated with reading achievement were doing homework, outside of class learning, and accessing math resources. In the final multiple regression model, however, finding math resources was not a significant contributor in predicting reading achievement, and outside learning was found to be highly intercorrelated with doing homework. This finding indicates that the best way to promote high reading achievement is through the use of technology in focused and specific ways which are designed by professional educators to promote student learning. Education professionals who understand the reading levels and learning needs of their students can prepare and assign work which will target those needs and produce the most desirable results.

Other types of laptop usage were not significantly correlated with high reading achievement but did appear to have a small positive effect on student achievement. These include reading political or international news, reading online messages, and collaborating with peers from the same school. Overall the model predicted 11% of student reading achievement scores, and the other four variables together accounted for less than 1% of that total. This means that while these activities are not detrimental, and should not necessarily be discouraged or limited by educators desirous of promoting reading achievement, they are not likely by themselves to contribute significantly to student reading achievement.

Resources and Skills Which Promote Teacher Use of Laptops

The qualitative interviews of teachers at the school provided valuable insights from which some conclusions can be drawn. The interviews revealed multiple benefits and opportunities which the laptop program provides for teachers and students at the school. One important benefit was preparation of students for the state standardized tests. Zheng et al. (2013) has argued that paper and pencil tests are not a good match for twenty-first century learners, and the movement to online test formats may be a positive development. However, the math teacher in particular argued that the format of online tests in math can be difficult for students, which means that having students practice typing math work is a strong potential benefit of the laptop program.

The teachers also mentioned the development of job skills, college skills, and closing the digital divide for students. This shows the importance role teachers feel the laptops play in helping to prepare students for the unique requirements of the twenty-first century world in which students live, a sentiment mentioned frequently in the literature (Borja, 2006; Chandrasekhar, 2009; Friedman, 2007; Sauers, 2012; Spires, Oliver, & Corn, 2012; Greenwood, 2007; Warschauer, 2006). One final benefit of the laptop program mentioned by two of the teachers is the benefits for student organization, which also echoes findings in the literature that laptops can benefit the development of student organizational skills (Carraher, 2014; Hoyer, 2011). Based on these findings, the researcher concludes that teachers do perceive significant benefits of the laptop program, and that those benefits meet clearly defined needs found in the research literature.

One key theme which emerged from the qualitative interviews was the importance of perseverance in bringing the laptops into the learning environment. Previous studies have shown that teachers may have difficulty implementing a laptop program effectively in their classrooms (Storz & Hoffman, 2013), that teachers' ability to do so is a key factor in the success or failure of such programs (Jones, 2013), and that commitment and persistence are vital for successful integration (Nielson, Miller, & Hoban, 2015). The qualitative findings of this study confirmed that integrating the laptops can be difficult, time-consuming, and confusing for teachers, particularly at first, but that through perseverance, and seeking out technical support, professional development opportunities, and developing classroom routines, ultimately successful integration can be achieved.

The final theme which emerged from the qualitative analysis was the importance of professional development for teachers when adopting a one-to-one laptop program. There is broad consensus in the literature that high quality professional development for participating teachers is one of the most important factors in the success of a one-to-one laptop initiative (Abell Foundation, 2008; Alberta Education, 2010; Blackley & Walker, 2015; Hoyer, 2011; Klieger et al., 2010; Lindqvist, 2015; Pack, 2013; Pogany, 2009; Storz & Hoffman, 2013; Topper & Lancaster, 2013; Warschauer et al., 2014; Zheng et al., 2016). The two teachers who reported the most success in integrating the laptops into their classroom instruction both reported that they had participated in extensive professional development beyond the initial training. They both reported that the professional development opportunities provided by the district had helped them to integrate the laptops into their instruction. The opportunities provided by the district appear to meet the need for ongoing professional development beyond one-time initial trainings identified by multiple sources in the literature (Jones, 2013; Plummer, 2012; Topper & Lancaster, 2013; Weber, 2012). One teacher also mentioned that she had taken advantage of tech support in the building, which enabled her to get additional help while she was implementing the ideas she learned in her training, an aspect of training that was emphasized by Klieger et al. (2010). The findings of this study add further evidence to support the claim that ongoing professional development is a key aspect of the successful integration of one-to-one laptops into the teaching and learning process.

Barriers and Obstacles to Teacher Use of Laptops

There were multiples barriers and obstacles to the use of the laptop identified by teachers in the qualitative interviews. One teacher in particular reported that she did not use the laptops in her classroom on a daily basis and reported that other teachers in the department used them even less often, perhaps never. She also reported that she did not find the initial professional development training provided by the district to be applicable to her particular curriculum area, and did not report having attended any additional trainings. The literature provides additional qualitative evidence that she is not alone in this experience. Beeson et al. (2014) reported that many teachers have found technology training to be irrelevant to their actual classroom work, and others have argued that technology trainings should be content area specific (Jones, 2013; Klieger et al., 2010; McKeeman, 2008) and focused on the needs of individual teachers (Hall &

Hord, 2001). It may be that there are inherent barriers to the use of laptops in math classes, as reported earlier in these findings. However, the fact that this teacher had found some ways to integrate the laptops, particularly in preparing students for college-level coursework and online standardized tests, does provide some evidence that there are ways for math teachers to integrate laptops that not all teachers at the school appear to be taking advantage of. This may be a potential opportunity for professional development programs specific to math teachers, and the use of the computers in math class is clearly an issue that school districts and schools should consider when adopting a one-to-one laptop program.

The finding that teachers appear to be more reluctant to assign homework to below-grade-level students indicates that teachers are using the laptops in different ways with different ability levels of students. This supports the findings of McKeeman (2008) that although one-to-one programs can help to provide equal access to technology, it is not a guarantee that they will be used in equal ways among all student demographics. Combined with the findings that the interviews revealed concerns regarding the impact of a lack of access to Wi-Fi at home on students, the findings of this study have potential implications for schools who desire to close the digital divide, an issue that will be addressed in more detail in the comparative section of this chapter.

One teacher advocated for systemic solutions to the lack of equal access to the Internet outside of the school, including funding access for low-income families and increased awareness of the issue on the part of teachers. Her call for equal access for all students echoes the sentiments of Nielson, Miller, and Hoban (2015), who argue that the lack of equal access to the Internet at home is a social justice issue which creates disparities for economically disadvantaged students, and Warschauer et al. (2014) who argue that a lack of Internet access at home is a barrier to full digital participation for disadvantaged students. Another teacher contributed some valuable potential solutions students, teachers, and schools could pursue, including providing access to materials at school that could be completed at home without Internet access, and providing opportunities such as study halls and off hours for students to complete laptop-dependent homework while still at school, a finding which supports those of Chandrasekhar (2009). It is clear that any district pursuing a laptop program must consider ways to ensure equality of access for students who do not have Internet access at home.

One other consideration that came out of the qualitative data was access to software and hardware. Districts must be cognizant of changes in software availability and access for teachers, and develop systems to ensure that teachers have access to the software they need. It is also important that when installing hardware, schools and districts ensure that all classrooms have equal access to Wi-Fi, and that hardware is adequately installed and maintained in school buildings. This supports the findings of other recent qualitative studies that technical disruptions or uneven classroom access to the Internet can be a significant barrier to the effective of integration of laptops into the learning process (Lindqvist, 2015; Nielson, Miller, & Hoban, 2015).

The adoption of a laptop program presents new challenges for teachers, who must find ways to manage the technology skillfully and effectively. Technical issues and the process of learning to use technology in new ways can result in the loss of class time, particularly in the early stages of adoption, a concern that was seen in all three teacher interviews, and which was also reported in a recent qualitative study of a laptop initiative (Jett, 2013). In addition, a recent meta-analysis of empirical studies of laptop initiatives found that a lack of technical support and fear of losing control in the classroom were a frequent cause of concern for teachers in incorporating laptops into their classroom instruction (Zheng et al., 2016). This could explain why the benefits of laptop programs can take years to manifest (Abell, 2008), and is an important consideration for districts considering the adoption of a laptop program.

The interviews also revealed significant attitudinal barriers to the adoption of the laptop program. Solutions must be found to manage the issue of some students not being willing or able to bring their laptops to class, an issue which is also mentioned in the research literature (Lindqvist, 2015; Nielson, Miller, & Hoban, 2015). In addition, teachers themselves may have a reluctance to use the laptops in their classes, particularly math teachers whose content area presents unique challenges when integrating the laptops, a finding that supports the findings of previous studies (Blackley & Walker, 2015; Burgad, 2008; Zuber & Anderson, 2013). These findings also found that a lack of comfort with potentially confusing new technology was a barrier to successful integration of the laptops, a finding that is also supported by the literature (Larkin & Finger, 2011). Districts and schools must be cognizant of the challenges which both teachers and students will face when in the process of adopting a laptop program.

Comparisons Between Qualitative and Quantitative Data

The qualitative interviews produced valuable findings which can be compared to the quantitative data in order to achieve triangulation. It is in this section that the strengths of the mixed-methods design of this study become clear.

Internet access at home. The quantitative statistics indicated that 11.5% of students at the school did not have access to reliable Internet connectivity at home, although only 2.5% reported that they had no Internet connectivity at all. However, even students who do have access to the Internet at home may still face barriers to accessing technology, particularly if there is only one computer and there are multiple family members, as Hatakka et al. (2013) have argued. The fact that 73% of students reported using their laptops for homework every day or most days is a strong indicator that many students have found the laptops useful, even those who have access to other computers. Pack (2013) has argued that laptop initiatives can unintentionally marginalize students who lack access to the Internet by disadvantaging students who are unable to access class materials at home, and Weers (2012) identified this as an important barrier to equal access. This belief was confirmed by one teacher who spoke out about the problems she has seen many of her students face due to a lack of access to the Internet at home, including problems with having to travel to locations where Internet is available in order to complete homework and an inability to turn in online assignments. Another teacher mentioned that concerns about access impact his teaching strategies, specifically with how he assigns homework. This shows that despite the quantitative evidence that students are still completing homework without access, the numerical data does not tell the whole story, and there are still barriers to equal access for those students who do not have reliable Internet access at home.

The between groups comparison showed that students without access to the Internet at home were not significantly less likely to use their laptops for homework than other students, though their mean usage was slightly lower. This may be because they have found strategies for using the laptops for homework which do not require them to access the Internet at home. One teacher reported helping the students download assignments in class so that they did not have to access the Internet in order to complete their homework. He also mentioned that students can access the Internet for homework during their study halls and off periods. Although the quantitative evidence indicates that those students may be finding ways to use the laptop computer to complete their homework, there is qualitative evidence to indicate that his might be placing an undue or unfair burden on them to find ways to access the Internet and complete their homework, an argument which is also expressed by Nielson, Miller, and Hoban (2015). This is a burden that is not shared by students with Internet at home, and is an important issue regarding equality of opportunity for all students, and the closing of the digital divide.

Use of Laptops in Math Classes. The quantitative evidence indicated that math teachers are far less likely to use the laptops than teachers in other core curriculum areas, and the qualitative evidence provided an explanation of that phenomenon. The unique attributes of math, including the need to include symbols and other marks, make typing more difficult for math students and teachers, while in other subject areas typing is often a faster way to complete coursework. Considering the evidence that standardized math tests are moving online, and that colleges may be using computers more often in their math classes, this points to an important need for additional professional development or other opportunities to help math teachers find ways to integrate the laptops into their classrooms in order to prepare students for online tests and for their future college coursework. The unique needs of math teachers are a factor that schools and districts should consider when adopting a one-to-one program.

Use of laptops and reading achievement. One of the most significant findings in the quantitative analysis was that using the laptop computers for homework and outside the classroom learning was significantly correlated with reading achievement. This finding supports the findings of Jett (2013), Kay (2010), and Shapley et al. (2010) which indicated that using laptops outside the classroom is one of the best indicators of student achievement. All three teachers reported that they are less likely to assign homework which requires the use of the laptops to their below-grade-level classes. Therefore, some of the relationships between homework and reading achievement could be due to ability grouping at the school, and teacher decisions regarding assignments of homework, a valuable reminder that correlation does not necessarily indicate causation and that other factors could factor in to the quantitative findings. Combined with the evidence of correlations between low reading achievement and activities which potentially distract students from learning, however, there is strong evidence pointing to the conclusion that using the laptops for academic purposes, as opposed to non-academic games and social networking, is strongly associated with high reading achievement. This finding provides evidence to support the conclusion that parents and teachers who want to promote high reading achievement should encourage the use of the laptops for learning, particularly the completion of homework, and discourage or limit the use of computers for games, social networking, and other non-academic activities.

One of the most surprising findings in the quantitative analysis was that the use of the laptops in Social Studies Classes was negatively correlated with reading achievement and in-class use of the computers was not significantly correlated with reading achievement in any of the other content areas studied. This study, however, did not differentiate between the different ways that students are using the laptops in their classrooms, which makes it impossible to determine whether specific types of usage of the laptops in class might be correlated with higher or lower reading achievement. This is an area that deserves further study, as will be discussed in the recommendations for further research section.

Recommendations for Practice

Based on the findings of this study, some recommendations for practice are offered. Schools and districts considering the adoption of a one-to-one laptop program should consider several factors including the need for patience and perseverance, the need for adequate professional development and technical support, the need to guide student usage of the laptops, and the need to consider the challenges of students who lack Internet access at home.

The findings of the review of literature and the findings of this study clearly indicate that schools and districts who adopt a laptop initiative must do so with long-term goals in mind. There will be a significant transition time, both for students and teachers, during which adjustments to the learning process to facilitate the incorporation of the laptops takes place. To expect immediate achievement results to manifest in the first one or two years of an initiative does not appear to be realistic. Some teachers may take more time than others to adopt the laptops into their instructional practices, and it is to be expected that some early difficulties will emerge through which teachers and students will have to persevere if the transition is ultimately going to be successful. Laptops are not a magic bullet that will produce immediate results; their successful integration involves a fundamental shift in the teaching and learning process which will require time and perseverance to achieve.

Another consideration which is important to consider is the need for adequate and ongoing professional development and technical support for teachers. Technical issues which are not anticipated are bound to emerge, and adjustments will be necessary in order to ensure equal access to Wi-Fi, hardware, and software applications. Districts must be prepared to respond to the needs of teachers, because technical issues can otherwise prove to be an insurmountable barrier to the integration of laptops into the learning process. Furthermore, teachers must be adequately trained, not only when the laptop program is first implemented, but in an ongoing way which will enable individual teachers to develop the strategies they need in order to achieve the successful integration of the laptops into the teaching and learning process. There is overwhelming evidence at this point in time to support the claim that teachers cannot implement laptop programs on their own, that there is a significant learning curve for teachers, and that there is a need for ongoing professional development to facilitate the adoption of a laptop program. It is also essential that districts understand the need for professional development tailored to the specific needs of individual teachers in individual content areas. One size fits all trainings are not likely to produce the desired results. Some departments, such as math, will need specialized professional development designed to help teachers understand the unique challenges of using computers for math work, and to prepare students for computerized assessments, and computer-based college coursework in their future. Every teacher will have a different level of technical expertise and unique needs, therefore group trainings should also be supplemented by individual technical support from knowledgeable and skilled individuals who can be resources for teachers as they put the ideas learned in professional development into practice.

Simply providing computers for student use is not likely to promote student achievement by itself. This study supports previous findings which indicate that students must be guided to use the laptops in ways which support the academic goals of a school or district that is adopting a laptop program. If students use the laptops to social network, play games, or participate in other non-academic activities the computers could have the opposite of the desired effect. Students who become distracted by the entertainment and socializing functions of computers are likely to have their learning undermined rather than enhanced by the laptops. The best uses of the laptops are for homework and learning purposes. Other uses should be discouraged and/or blocked when possible by filters and other measures. Laptops that are provided to students for learning should be viewed as tools, not as toys, if they are expected to enhance the learning process.

One final consideration for practice when implementing a laptop initiative is the consideration of students who lack Wi-Fi access at home. Closing the digital divide is an important aspect of a successful laptop initiative, and there is significant evidence to support the claim that students who lack such access at home are put at a unique disadvantage compared to students with access. The ability to use the laptops away from school for homework and studying is an important aspect of a one-to-one initiative, an aspect that separates from the computer-lab model of providing computers for student use only at school. Particularly in light of the correlation with the use of the laptops for homework and reading achievement found in this study, it is imperative that all students are able to take full advantage of the laptops for learning. Strategies such as using the Wi-Fi access at school in order to download assignments before taking them home and providing study halls or other opportunities for students to complete homework on the school-provided Wi-Fi can help to alleviate this problem. Districts may also consider pursuing programs which could provide solutions to the access of Wi-Fi at home through other means such as grants, funding, and community access programs.

As more and more districts and schools adopt one-to-one laptop programs, an understanding of the characteristics of a successful laptop program is essential. Simply providing computers to all students is not, in and of itself, enough to ensure that the program will adequately meet the needs of twenty-first century teachers and learners.

Recommendations for Further Research

More information is needed about the impact of using laptops in class and reading achievement. This study yielded important findings regarding the specific ways students should best use their laptops outside of class because it was designed to assess the specific ways in which students were using their laptops outside of class, rather than merely measuring their overall quantity of laptop usage. However, the findings that using the laptops in class were not correlated with reading achievement indicate that more information is needed about the specific ways in which students are using the laptops in class in order to determine whether some types of usage are correlated with higher or lower reading achievement. A study similar to this one, designed to assess the specific types of activities which are being done in class, could provide valuable information, and shed more light on the specific types of in-class activities which are correlated with both high and low reading achievement.

Final Thoughts

A generation of students who have never known a world without computers and the Internet is a generation for whom the integration of technology into the learning process is not only valuable, but perhaps necessary. As the education system adjusts to this new reality, rapid changes require a thorough understanding of how technology can be successfully integrated into the teaching and learning process. This study, by looking closely at the ways in which teachers and students are using laptop computers as part of a long-term and successful laptop initiative, has sought to add to our understanding of technologies' role in education. It is clear that there are no easy answers, but that even in this quickly evolving field of study we are making progress in understanding the barriers and opportunities that such programs create for students and teachers, and the complex role that technology plays in the promotion of student achievement. The days in which educators could dismiss technology as inessential or peripheral to the learning process are long gone. As ubiquitous computers and the rise of technology has transformed our world, it has also transformed how students write, research, communicate, socialize, work, and play. And perhaps even more importantly for educators, it has transformed how they think and how they learn. The more we understand about those changes, the better position we will find ourselves in as we continue to work to meet the needs of a generation unlike any that has come before. It can be seen as an overwhelmingly scary and sudden dramatic change, but it can also be seen as a great adventure into a future that holds nothing if it doesn't hold even more and greater surprises. It is in the spirit of that adventure that I offer this dissertation.

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APPENDICES

Appendix A

Consent to Participate in a Research Study
Colorado State University

TITLE OF STUDY: One-to-one Laptops in a Public Secondary School: Teachers' Usage and the Impact on Achievement

PRINCIPAL INVESTIGATOR: Gene Gloeckner, Ph.D., Professor, School of Education, Colorado State University

CO-PRINCIPAL INVESTIGATOR: E. Jason Clarke, Doctoral Candidate, School of Education, Colorado State University

WHY AM I BEING INVITED TO TAKE PART IN THIS RESEARCH? As a teacher at FCHS you have been a part of the laptop initiative which has provided 24-hour access to a laptop computer for each student and teacher at your school. The impact that this program has had on your beliefs about the role of technology in teaching and learning, your teaching practices, and the use of technology in the classroom is of interest to many education professionals who want to understand how laptop programs impact students and teachers in our schools.

WHO IS DOING THE STUDY? This study is being conducted by E. Jason Clarke, doctoral candidate at Colorado State University under the supervision of his advisor, Professor Gene Gloeckner from the Department of Education at Colorado State University.

WHAT IS THE PURPOSE OF THIS STUDY? The purpose of this study is to determine what impact (if any) the laptop program has had on you and your students and your individual classroom.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST? We will be analyzing data from an interview that we conduct with you in order to assess the impact of the program on your classroom. The interview will take place at your school or location that is convenient for you and may take from 1-2 hours to complete, depending on the length of your answers and your willingness to share your ideas. You have the right to end the interview at any time.

WHAT WILL I BE ASKED TO DO? In a one-on-one interview you will be asked questions about the laptop program. We ask that you respond honestly and thoroughly so that we can accurately assess your experience and perceptions of the program. With your permission, the interview will be audiotaped and transcribed by the Co-Principal Investigator, Jason Clarke.

ARE THERE REASONS WHY I SHOULD NOT TAKE PART IN THIS STUDY? If you are not willing to respond to the questions or do not feel comfortable responding to the questions you may choose not to participate in the study.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

- You are asked to dedicate your time (The interview contains approximately 17 questions) and to be honest about your experiences, which may pose a risk of discomfort to you. If you are not comfortable talking about your experiences in the laptop program then you are more likely to experience discomfort in responding to the interview questions. If for any reason you feel the need to discuss this study and/or its impact on you, our students, or our school with an administrator or counselor you have the right to do so.
- It is not possible to identify all potential risks in research procedures, but the researcher(s) have taken reasonable safeguards to minimize any known and potential but unknown, risks.

ARE THERE ANY BENEFITS FROM TAKING PART IN THIS STUDY? There are no benefits to participating in this study to you personally. Developing a greater understanding of the impact of laptop programs, however, may contribute beneficial findings to the field of education and may be used to help guide education leaders who are developing or organizing the implementation of such programs in the future as well as educators who are participating in technology initiatives.

DO I HAVE TO TAKE PART IN THE STUDY? Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

WHO WILL SEE THE INFORMATION THAT I GIVE? We will keep private all research records that identify you, to the extent allowed by law. Your real name will not be used in any published research based on this study, nor will any identifying characteristics such as your age, gender, or department be used in any publications based on this research. We may publish the results of this study; however, we will keep your name and other identifying information private. You should know, however, that there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court OR to tell authorities if we believe you have abused a child, or you pose a danger to yourself or someone else. We may also be asked to share the research files with the CSU Institutional Review Board for auditing purposes.

WHAT ELSE DO I NEED TO KNOW?
The researchers would like to audiotape your interview to be sure that your comments are accurately recorded. Only our research team will have access to the audiotapes, and they will be destroyed when they have been transcribed. Do you give the researchers permission to audiotape your interview? Please initial next to your choice below.

- ☐ Yes, I agree to be digitally recorded ______ (initials)
- ☐ No, do not audiotape my interview _____ (initials)

WHAT IF I HAVE QUESTIONS?
Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, E. Jason Clarke at Jason.clarke@colostate.edu or Professor Gloeckner at Gene.Gloeckner@colostate.edu. If you have any questions about your rights as a volunteer in this research, contact the CSU Institutional Review Board at 970-491-1553. We will give you a copy of this consent form to take with you.

Your signature acknowledges that you have read the information stated and willingly sign this consent form. Your signature also acknowledges that you have received, on the date signed, a copy of this document containing 2 pages.

_______________________________________ ____________________
Signature of person agreeing to take part in the study Date

____
Printed name of person agreeing to take part in the study

E. Jason Clarke ____________________
Name of person providing information to participant Date

____
Signature of Research Staff

Appendix B

Teacher Interview Protocol

1. How often do you use the laptops in your classroom?
2. Are there some classes, grade levels, or ability levels for which you use the laptops more or less often?
3. Do you think you use them more or less often than other teachers?
4. Why do you think you use them more than or don't use them as much as other teachers?
5. What kinds of things do you use the laptops for in class?
6. Have you faced any problems or challenges in trying to use the laptops in your classroom to promote student learning?
7. Have you observed any benefits to student learning or achievement when using the laptops in your classroom?
8. What PD or trainings have you received to help you use the laptops? How effective was that training?
9. What characteristics do you think would have made the training more effective?

Appendix C

Parental Consent to Participate in Student Survey

Professor Gene Gloeckner, Principal Investigator
E. Jason Clarke, Co-Principal Investigator
Colorado State University

Because your student has been provided a laptop by the school district, we have selected him or her to participate in a study of how often the laptops are being used by students and teachers for learning-related purposes and whether that use has had an effect on student achievement.

Your student will be asked to take a 15-minute survey during class time to answer five questions about how he or she uses the district provided laptop computer for learning. Your student's participation in this study is completely voluntary, and if you do not wish for your student to participate he or she will not be penalized in any way. However, this information may be helpful to us in understanding how often the laptops are being used by students and faculty here at FCHS and whether they are improving student achievement. This information is important both for understanding this laptop program and for analyzing whether similar programs should be implemented in the future, either here at FCHS or at other schools around the country.

We may publish the results of this study; however, we will keep your student's name and other identifying information private to the extent allowed by law. Only the combined results from all students will be reported. Your student's name and identifying characteristics will not be used in any published research based on this study. You should know, however, that there are some circumstances in which we may have to show your student's information to other people. For example, the law may require us to show your information to a court OR to tell authorities if we believe he or she poses a danger to him or herself or someone else.

You have the right to stop your student from taking the survey by signing and returning this opt-out form, or by emailing the researcher with a request to opt-out. Your student will also he informed that he or she has the right to skip any questions that he or she feels uncomfortable with or that he or she does not wish to respond to. Upon completing this survey your student's participation in this research study will be concluded, and no additional surveys, interviews, or any other follow-up activities will be requested of him or her.

If you have questions about this study you can contact the investigator, E. Jason Clarke at Jason.clarke@colostate.edu or by calling him at 970-488-8180, or you can contact Professor Gloeckner at Gene.Gloeckner@colostate.edu. If you have any questions about your student's rights as a volunteer in this research, contact the CSU Institutional Review Board at RICRO_IRB@mail.colostate.edu; 970-491-1553.

If you agree to allow your student to participate in the study by completing the 15-minute survey during his or her English class, you do not need respond to this request. If you do not wish for your student to participate, contact the researcher at 970-488-8180; Jason.Clarke@colostate.edu on or before _________, 2016, and request that your student not participate.

Thank you!

Jason Clarke
Doctoral Candidate & Co-Principal Investigator
Colorado State University
Gene Gloeckner, Ph.D.
Professor and Principal Investigator
School of Education
Colorado State University

Appendix D

Student Consent to Participate in Student Survey

Professor Gene Gloeckner, Principal Investigator
E. Jason Clarke, Co-Principal Investigator
Colorado State University

I am a researcher from Colorado State University. We are studying the laptop program at your school district. Because you are a student at FCHS, and have been issued a laptop by the school district, we have selected you to participate in a study of how often the laptops are being used by students and teachers for learning-related purposes and whether that use has had an effect on student achievement.

You are invited to take a survey that will take about 15 minutes during your class time. Your participation in this study is completely voluntary, and if you do not wish to participate you will not be penalized in any way. However, this information will be very useful to us in understanding how often the laptops are being used by students and faculty here at FCHS and whether they are improving student achievement. This information is important both for understanding this laptop program and for analyzing whether similar programs should be implemented in the future, either here or at other schools around the country.

We will keep private all survey results that identify you, to the extent allowed by law. We may publish the results of this study; however, we will keep your name and other identifying information private. You will not be identified in any written materials published by the research team. When we share the results of the study, we will share the combined results from all students. You should know, however, that there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court OR to tell authorities if we believe you pose a danger to yourself or someone else. If for any reason you feel the need to talk about the study or its impact on you as a student you have the right to discuss it with your counselor, your teacher, or an administrator. If you feel sick or unwell at any time and need to see the school nurse, please excuse yourself and do so. Please get a nurse’s pass from your teacher before you leave, if possible.

You have the right to stop taking the survey and/or to skip any questions that you feel uncomfortable with or that you do not wish to respond to. Upon completing this survey your participation in this research study will be concluded, and no additional surveys, interviews, or any other follow-up activities will be requested of you.

If you have any questions, please ask now. If you have any questions about your rights as a volunteer in this research, please contact the CSU Institutional Review Board at 970-491-1553.

If you agree to participate in the study please click the “I agree” button below to begin the survey. If you do not wish to participate, simply exit from this page at this time.

Thank you!

Jason Clarke
Doctoral Student
Colorado State University

Appendix E

Student Survey – Administered on Google Forms

1. How often do you use your PSD provided laptop for learning purposes outside of the classroom?
   (Note: "Learning" doesn't have to be school-related. It can include any time you spend reading on your computer, finding facts, searching for information, connecting with experts, exploring a topic you are interested in, writing, sharing ideas and information, collaborating with others creatively, OR doing homework or school-related work)
   a. Every Day
   b. Most Days
   c. Sometimes
   d. Rarely
   e. Never

2. Do you have Internet access at home?
   a. Yes
   b. I had access sometimes (i.e. it was very slow or unreliable)
   c. No

3. If you have access to one or more computers other than your PSD provided laptop (including a smart phone, smart TV, iPad, desktop, laptop, or other device) how often do you use non-PSD provided computers for learning purposes?
   a. Every Day
   b. Most Days
   c. Sometimes
   d. Rarely
   e. Never

4. How often do you use your PSD provided laptop for learning during class time in your English language arts class?
   a. Every Day
   b. Most Days
   c. Sometimes
   d. Rarely
   e. Never

5. How often do you use your PSD provided laptop for learning in your science class?
   a. Every Day
   b. Most Days
   c. Sometimes
   d. Rarely
   e. Never

6. How often do you use your PSD provided laptop for learning in your social studies class?
    a. Every Day
    b. Most Days
    c. Sometimes
    d. Rarely
    e. Never

7. How often do you use your PSD provided laptop for learning in your math class?
    a. Every Day
    b. Most Days
    c. Sometimes
    d. Rarely
    e. Never

8. On a scale of 0 - 4, how often do you use your laptop for each of the following activities?
   4 = Every Day; 3 = Most Days; 2 = Sometimes; 1 = Rarely; 0 = Never
    a. Doing Homework
    b. Creative Writing
    c. Writing Blogs, Comments, or Posts on websites or apps
    d. Conducting Research
    e. Analyzing Data or Information
    f. Contributing Research, Data, or Information to Online Databases (i.e. Wikipedia, Guitar Tab Archive, MobyGames, GameRankings, Internet Movie Database, etc.)
    g. Collaborating with peers from FCHS on creative or intellectual projects
    h. Collaborating with peers from outside FCHS on creative or intellectual projects
    i. Connecting with experts (i.e. retweeting, @tagging, posting comments on YouTube or Instagram, liking or re-posting, etc.)
    j. Connecting with celebrities (i.e. retweeting, @tagging, posting comments on YouTube or Instagram, liking or re-posting, etc.)
    k. Accessing Math Resources
    l. Reading Political or International News
    m. Reading Sports News
    n. Reading About People/Bands/Actors/Artists
    o. Watching Videos
    p. Playing Multi-Player Online Games
    q. Playing Single-Player Games
    r. Social Networking with friends (Snapchat, Instagram, Twitter, Pinterest, etc.)
    s. Social Networking with family (Snapchat, Instagram, Twitter, Pinterest, etc.)
    t. Reading Email, Text Messages, or Social Networking Messages
    u. Other

Appendix F

Student Participant Recruitment Script

Professor Gene Gloeckner, Principal Investigator
E. Jason Clarke, Co-Principal Investigator
Colorado State University

Hello, my name is Mr. Clarke and I am an English teacher here at Fort Collins High School. I am also a student at Colorado State University where I am in a doctoral program studying education science. As part of my program I am doing a research project about the laptop program here at FCHS. I am interested in finding out how you use your laptops for learning, both in class and out of class and how often you use your district-issued laptop for learning purposes.

For the purposes of this study I am defining learning very broadly. Learning can be something you are doing for school, like homework or classwork, but it could also be learning you are doing on your own, such as looking up information, communicating or collaborating with others, creating online content such as posts or comments, pretty much anything other than playing non-learning games or watching non-informational videos.

In order to find out how you use your laptops I need your help, so your teacher has been kind enough to give me a few minutes to conduct a survey. This survey will simply ask what you use your laptop for and how often you use it for learning purposes.

I may publish the results of this study, but if I do your name or personal information won't be identifiable in any way. I will report only statistical averages, not individual students' data. Your parents have also been contacted about this study, and should have given their consent for you to participate. If for any reason you don't think your parents would want you to take this survey, or if you know that they have not given their consent for you to participate, you should not take the survey at this time.

If you are willing to participate in this study, go to the website ______ and read the information you find there. If you still want to participate, click "I agree" and answer the questions as honestly and accurately as you can. If you don't understand a question, feel free to raise your hand and ask me to explain it. If you aren't sure about exactly how much time you spend on any given activity, just make your best guess. If you don't have any idea how much time you spend on any given activity, just leave that question blank. If you don't want to answer a question, you don't have to. You can quit taking the survey at any time and you won't get in trouble or lose any points for this class.

Any questions? Then if you want to take the survey, go ahead and access the web site now.

Appendix G

Letter of Approval to Conduct the Study from Poudre School District

POUDRE
SCHOOL
DISTRICT

3/11/16

Dr. Gloeckner and Jason Clark,

Please consider this document as formal approval for you to conduct research within Poudre School District (PSD) based on your application materials originally received 3/13/16. Research project name: "One-to-one Laptops in a Public Secondary School: Usage and the Impact on Achievement."

* Date of project: Between March 2016 and June 2016 (If additional time is needed to complete the study, please notify me via email).

* I would like to add two conditions: 1) It is requested that the researcher provide PSD an electronic copy of the project summary at the end of the project, and 2) if you decide to submit an article for publication, please provide an electronic version of the article to PSD when completed.

* Priority consideration for future research partnerships with PSD will be given to individual researchers that have a demonstrated track record of submitting final reports for PSD consideration.

* Please feel free to use this email in your correspondent with PSD schools and personnel regarding this research project.

This approval letter signifies that you have successfully met all PSD criteria for conducting research within PSD. Approval from building principals where research activities may occur is also needed prior to beginning research activities at any particular PSD school. Providing principal(s) with a copy of this letter is an important step in your communication with principals, but please keep in mind that principals have the right to refuse to participate in any proposed research activities that involve the students, teachers, or facilities that they are responsible for. Furthermore, a principal or the superintendent of PSD may exercise their right of refusal at any point during the implementation of an authorized research proposal. The district and its schools may not be directly or indirectly identified in any published material related to your research unless specifically authorized in advance and in writing by the superintendent of Poudre School District.

Thank you for considering Poudre School District as a research partner. Please feel free to contact me if you have any questions, and I look forward to reading your findings.

Dwayne Schmitz

Dwayne Schmitz, Ph.D. | *Director of Research and Evaluation*

POUDRE SCHOOL DISTRICT

970-490-3693
dschmitz@psdschools.org

What would you do if you knew you would not fail?

2407 LaPorte Avenue · Fort Collins, CO 80521-2297 · (970) 482-7420

Appendix H

Letter of Permission to Conduct the Study from FCHS Principal

FORT COLLINS HIGH SCHOOL
3400 Lambkin Way
Fort Collins, CO 80525-5727
(970) 488-8021
Fax (970) 488-8008

Mark Eversole
Fort Collins High School
3400 Lambkin Way
Fort Collins, CO 80525

To Dwayne Schmitz:

I have spoken with Jason Clarke regarding his proposal to conduct research here at Fort Collins High School. I hereby grant him permission to conduct the study for his dissertation project as part of his doctoral program at Colorado State University. He has my permission to interview teachers who agree to participate in his study and to survey students in the 9th and 10th grade using the survey instrument which he has shared with me.

I understand that this will take 10-15 minutes of class time and he has assured me that participation will be voluntary for both teachers and students, and that he will obtain written consent from both groups of participants. He has also assured me that he will seek parental consent through an opt-out letter that will be sent to parents by email in advance of the survey date, informing them of the nature of the study and seeking their consent for their student to participate.

My approval is contingent upon approval by your office and the approval of the Human Subjects Institutional Review Board at Colorado State University.

Thank you,

Mark Eversole
Principal

POUDRE SCHOOL DISTRICT

Appendix I

Letter of Approval to Conduct the Study from the
Colorado State University Institutional Review Board

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE: May 03, 2016
TO: Gloeckner, Gene, 1588 School of Education
Clarke, Jason, 1588 School of Education, Kamberelis, George, 1588 School of Education
FROM: Swiss, Evelyn, CSU IRB 2
PROTOCOL TITLE: One-to-one Laptops in a Public Secondary School: Usage and the Impact on Achievement
FUNDING SOURCE:NONE
PROTOCOL NUMBER: 16-6496HH
APPROVAL PERIOD: Approval Date: May 02, 2016   Expiration Date: March 28, 2017

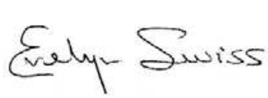
The CSU Institutional Review Board (IRB) for the protection of human subjects has reviewed the protocol entitled: One-to-one Laptops in a Public Secondary School: Usage and the Impact on Achievement. The project has been approved for the procedures and subjects described in the protocol. This protocol must be reviewed for renewal on a yearly basis for as long as the research remains active. Should the protocol not be renewed before expiration, all activities must cease until the protocol has been re-reviewed.

Important Reminder: If you will consent your participants with a signed consent document, it is your responsibility to use the consent form that has been finalized and uploaded into the consent section of eProtocol by the IRB coordinators. Failure to use the finalized consent form available to you in eProtocol is a reportable protocol violation.

If approval did not accompany a proposal when it was submitted to a sponsor, it is the PI's responsibility to provide the sponsor with the approval notice.

This approval is issued under Colorado State University's Federal Wide Assurance 00000647 with the Office for Human Research Protections (OHRP). If you have any questions regarding your obligations under CSU's Assurance, please do not hesitate to contact us.
Please direct any questions about the IRB's actions on this project to: IRB Office - (970) 491-1553; RICRO_IRB@mail.Colostate.edu

Evelyn Swiss, Senior IRB Coordinator - (970) 491-1381; Evelyn.Swiss@Colostate.edu
Tammy Felton-Noyle, Assistant IRB Coordinator - (970) 491-1655; Tammy.Felton-Noyle@Colostate.edu



Swiss, Evelyn

Approval is to recruit up to 750 participants with the approved recruitment, parent opt-out letter, and student assent. Because of the nature of this research, it will not be necessary to obtain a signed consent form. However, all subjects must receive a copy of the approved cover letter. The requirement of documentation of a consent form is waived under § _ _.117(c)(2). The requirement to obtain signed parental permission has been waived under § _ _.45 CFR 46.408(c)

Approval Period: May 02, 2016 through March 28, 2017

IRB Number: 00000202

Appendix J

Consent to Participate in a Research Study
Colorado State University
(Addendum)

TITLE OF STUDY: One-to-one Laptops in a Public Secondary School: Teachers' Usage and the Impact on Achievement

PRINCIPAL INVESTIGATOR: Gene Gloeckner, Ph.D., Professor, School of Education, Colorado State University

CO-PRINCIPAL INVESTIGATOR: E. Jason Clarke, Doctoral Candidate, School of Education, Colorado State University

The previous permission form signed by all study participants indicated the following:

WHO WILL SEE THE INFORMATION THAT I GIVE? We will keep private all research records that identify you, to the extent allowed by law. Your real name will not be used in any published research based on this study, nor will any identifying characteristics such as your age, gender, or department be used in any publications based on this research. We may publish the results of this study; however, we will keep your name and other identifying information private. You should know, however, that there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court OR to tell authorities if we believe you have abused a child, or you pose a danger to yourself or someone else. We may also be asked to share the research files with the CSU Institutional Review Board for auditing purposes.

Due to unanticipated qualitative findings and the resulting conclusions of the researcher, which are department specific, the research team requests that participants agree to the following modifications and clarifications of the section of the permission form quoted above.

WHO ELSE WILL SEE THE INFORMATION THAT I GIVE? The above conditions will be adhered to, with the exception of the clause which indicates that "your age, gender, or department" will not be identified. The researchers request that you consent to the identification of your department in the findings and discussion section of the research study. The findings and discussion section of the research study have been attached for your review. Sign below only if you agree that these findings accurately reflect your opinion and the statements you made during the interview, and only if you are comfortable with this presentation of the findings and discussion, including the identification of your specific department.

This research study will be published and disseminated in the form of a dissertation, and a version of it may be published at a later date in a research journal or other publication for public distribution. The results of this study will also be shared with school and district administrators and other Poudre School District employees as part of the research agreement between the researchers and PSD.

Your signature acknowledges that you have read the information stated above and willingly sign this consent form. Your signature also acknowledges that you have received, on the date signed, a copy of this document.

____ _____________________
Signature of person approving the findings of the study Date

____
Signature of person approving the findings of the study

____E. Jason Clarke_____________________________ _____________________
Name of person providing information to participant Date

____
Signature of Research Staff