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1:1 laptop implications and district policy considerations

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by

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ABSTRACT

Background: The state of Iowa has seen a drastic increase in the number of schools that provide one laptop for each student. These 1:1 schools have invested large amounts of time and money into becoming a 1:1 school. The current research on 1:1 schools is sparse, and policy makers are actively trying to evaluate those programs.

Purpose: To assess the effects of 1:1 laptop programs across the state of Iowa on time students use technology, integration of technology, and teacher competency with technology.

Setting: There were 110 public high schools across the state of Iowa that were included in this study, and 37 of those were 1:1 schools.

Subjects: Data were collected for both the school and teachers. A total of 922 teachers at 110 schools filled out the survey completely and were included in the study.

Research Design: Schools were initially identified for the study using propensity score matching. A propensity score was generated for each school, and treatment and control schools were matched based on their propensity score. Once schools had been identified multi-level models were created for the three separate dependent variables of interest in this study.

Data Collection and Analysis: Data on schools were collected from the Iowa Department of Education and the Common Core of Data. Teacher level data were collected using a survey that was based off of a survey created by Hutchison and

Reinking (2011). Each of the three research questions in the study was analyzed with four separate multi-level models.

Findings: Significant differences were identified between 1:1 educators and their non-1:1 peers. Teachers in 1:1 schools reported that their students used technology more frequently, and 1:1 educators also reported higher integration scores. The remaining finding indicated that 1:1 educators reported that they had higher competency levels with technology than other educators.

Conclusions: This study demonstrates that a 1:1 program is one way for schools to increase students' access and exposure to technology. It also indicates that 1:1 schools appear to develop their teachers' skill set with technology better than other schools.

CHAPTER 1: INTRODUCTION

Between the 2010 and 2011 school years, the number of 1:1 laptop programs in the state of Iowa nearly doubled. That growth put the number of programs in the state at approximately 90 schools, which means that nearly 25% of the school districts in the state of Iowa have some type of 1:1 program. If the recent explosion in growth is any indicator, it appears that number will continue to climb in the future.

Although there are multiple reasons for implementing a 1:1 laptop initiative, it is certainly seen by most educators as a major transformation. Penuel (2006) listed four goals that are most common for schools transitioning to a 1:1 program. Each of these reasons could stand alone as a major change initiative, and they are all of monumental interest in education today. Those reasons included improved academic achievement, increased equity, increased economic competiveness of a region, and/or transforming the quality of instruction. If 1:1 initiatives help schools achieve these goals, many will view their 1:1 investment as worthwhile.

With the perceived benefits of 1:1 education, there are also concerns that exist. Some see providing one laptop for every student as a major expense and questions arise as to whether the benefits outweigh the costs. Even some who have implemented 1:1 programs later dropped them because they did not see positive results (Hu, 2007). Many educators consider technology integration in schools in general as a failure. Technologies such as film, radio, and early computers each entered education with great hype and promises of transforming schools, but none did. The barriers that impeded successful integration with those technologies may also potentially impede 1:1 schools.

For many schools and educational leaders, a 1:1 program is their way to drastically change the educational landscape. They see it as a way to help change the way that teachers teach and students learn. For some, a 1:1 program is their "silver bullet." With all of these multiple perspectives and beliefs, it is important to investigate the true impact that 1:1 laptop initiatives have had on our schools, students, and teachers.

Statement of the Problem

Over the past three years, the number of 1:1 schools around the nation and, in particular the state of Iowa, has grown drastically. As school leaders have made the decision to move to a 1:1 environment, they have had to make major investments of time, money, and other resources in the initiative. Although schools choose to become 1:1 schools for various reasons, schools expect change with such a major initiative.

Unfortunately, the literature on the topic of 1:1 programs is somewhat limited. Much of the research has been on schools that are in the infancy stages of their program. Many of the studies have also been limited to very small sample sizes, and they have only focused on certain aspects of a 1:1 program. The reported results from studies vary and inconsistent results have been reported.

Purpose of the Study

The purpose of this study was to examine the impact the 1:1 initiative has had on schools. State data were used to create a model that compared 1:1 schools with similar non-1:1 schools. Teacher surveys also were used to collect data to analyze what was happening in classrooms. Survey results attempted to uncover the relationship between schools' 1:1 status and student time using technology, technology integration, and teacher competency with technology.

Theoretical Framework

This study's design and research questions were connected to two frameworks: Rogers' Diffusion of Innovation Theory and the Technology, Pedagogy, and Content Knowledge (TPACK). Both models were viewed as guides to follow when analyzing the wide scale implementation of technology in schools.

Rogers' Diffusion of Innovation Theory (2003) has been used widely by researchers to analyze the implementation of various innovations. Technology in schools can certainly be viewed as an innovation, and educators are trying to closely analyze its impact and implementation. Rogers (2003) identified five stages to the adoption process. Those stages are knowledge, persuasion, decision, implementation, and confirmation. The knowledge stage simply involves gaining knowledge of an innovation. The persuasion stage occurs when individuals develop a positive or negative view of that innovation based on information gained during the knowledge stage. The decision stage involves the choice of whether or not to adopt the innovation and during the implementation stage the innovation is put into practice. During the confirmation stage, individuals decide whether to continue adoption of or discontinue and reject the innovation. Digital technology in schools is a unique innovation, and must be closely viewed through this framework for innovation.

At its core, 1:1 implementation is a system-wide decision that is typically made by some type of school leader. For that reason, the decision whether or not to adopt a 1:1 program is essentially out of the hands of an individual teacher. However, the ways in which teachers use that technology can be analyzed through this framework. Within individual classrooms, teachers make the decisions regarding how they use technology and the frequency with which they use that technology. The first two research questions in this study are measures of how teachers are using technology in the classroom. These questions essentially get at the confirmation stage of Rogers' framework by measuring the ways and frequency that technologies are being used. Although the other stages of this framework are equally important, policymakers are intently interested on the outcomes from the wide scale adoption of technology in the classrooms.

The second theoretical framework for this study was the Technology, Pedagogy, and Content Knowledge (TPACK) model, which posited the complex roles of - and relationship between - technology, pedagogy, and content knowledge (Mishra & Koehler, 2006). The TPACK framework is closely related to a model Shulman (1986) described in relation to content knowledge and pedagogical knowledge. Shulman highlighted how the focus in education had shifted from content knowledge around the turn of the century to pedagogical knowledge around the time his article was published. Like things often happen in education, Shulman saw this as a major shift from one extreme to the other. His article highlighted a teachers examination from 1875 that was nearly entirely content-focused compared to the focus in the 1980s, which was almost entirely pedagogically focused. In a later paper, Shulman (1987) wrote about how effective teachers blend the content and pedagogy into an understanding of particular topics or problems rather than focusing on them in isolation. In that paper he described pedagogical content knowledge, which represented the blending of content and pedagogy in order to effectively deliver instruction. Mishra and Koehler (2006) extended Shulman's concept to apply to technology in education. Their TPACK framework focused on the importance of the blending of technology, pedagogy, and content knowledge.

One very important concept of TPACK is understanding the relationships and interactions between technology, pedagogy, and content knowledge (Harris, Mishra, & Koehler, 2009). Like Shulman, Mishra and Koehler (2006) claimed that often the three areas are isolated from one another. Schools, for example, may focus their professional development solely on technology software and hardware. That approach leaves teachers ill-equipped to successfully integrate technology into their classroom. The TPACK model instead focuses on all three areas and, more importantly, the ways in which those three areas interact with one another. Effective teachers are able to use technology, pedagogy, and content knowledge together to deliver more effective instruction. The TPACK model is essentially a model of effective technology integration.

The third research question in this study is central to the TPACK model. That question analyzed the technology competency that teachers reported. The TPACK framework asserts that technology knowledge is one of three important components needed to improve technology integration. Holding pedagogy and content knowledge constant, this model would predict that teachers with more technology knowledge would do a better job integrating technology into their classrooms.

These two frameworks seem to naturally align with research around innovation of technology in schools. Rogers' framework is extremely relevant to any conversations around innovation, and the TPACK framework may be the leading model for technology integration in schools. The research questions for this study aligned with these two frameworks.

Research Questions

The following research questions were used to guide this study:

1. Do teachers at 1:1 schools report that their students use technology *more frequently* than teachers at non-1:1 schools?
2. Do teachers at 1:1 schools report that they *integrate* technology differently than teachers at non-1:1 schools?
3. Do teachers at 1:1 schools report higher levels of *technology competency* than teachers at non-1:1 schools?

Significance of Study

This study on the impact of the 1:1 initiative on schools is significant for multiple reasons. The current, but not unusual, mood in education is certainly that of reform. In particular, many educators, politicians, and countless others are talking and writing about how we are inadequately preparing our students. Wagner (2008) wrote about the seven survival skills that students need, but are not getting from schools. Many others have thrown around the term “21st century skills” when referencing the things we need to prepare our students to know and be able to do. For many, a 1:1 program has been the tool to spark change. This study strived to identify whether or not 1:1 status has resulted in actual transformation in schools. The research questions listed above should be of particular interest to educators who are continually trying to move their schools forward with the assistance of technology. The questions around time and integration are evaluating whether or not 1:1 teachers are more likely to adopt technology. The third research question relating to competency could be used as an indicator of whether 1:1

teachers are more likely to be able to integrate technology effectively based on the TPACK framework.

The sample size of this study is also beneficial to educators and policymakers. Much of the current research on 1:1 programs has been restricted to studies within a district or even a school. Results have been varied, and there is little consensus on the impact of 1:1 initiatives on schools. Including nearly forty 1:1 schools in this study provided much better insight into the impact of 1:1 programs on schools.

Limitations

For the purpose of this study, the sample was delimited to schools that were not in their first year of a 1:1 program. The teacher sample included teachers at the selected schools with email addresses that were available to the researcher. School administrator data was limited to available information from the Iowa Department of Education.

Like most studies involving surveys, this study had additional limitations. Although methods were put in place to increase the response rate, there were still a large number of individuals in the sample who did not participate. This limitation potentially impacted the study if those who responded were dissimilar to the rest of the sample and the population. Another limitation was there were not observations or surveys from other groups such as students to validate the teacher surveys.

The study was also restricted to schools in Iowa. Although this may have potentially limited the generalizability of the study, it also increased the ability to generate comparable control and treatment groups.

Summary

This study sought to inform policymakers and other educators about the impact of 1:1 initiatives on schools. The findings of this study should provide assistance to schools as they consider transitioning to a 1:1 environment as well as highlighting possible ways to effectively implement a 1:1 program.

This chapter contained an overview of the study including the statement of the problem, purpose, theoretical framework, research questions, significance of the study, limitations, and definition of terms. Chapter 2 provides an overview of the literature reviewed for this dissertation. The review of literature is divided into three major sections. The first section looks at the history of technology in education for the past 100 plus years. The next section is a review of technology integration in education. Finally, the current research surrounding 1:1 schools is presented. Chapter 3 begins with a brief overview of the study as well as a section with the research questions. The remaining sections in the chapter will include research design and methodology, population and sample, data collection methods, survey administration, study variables, data analysis, limitations, and ethical issues. Chapter 4 is an overview of the results of the statistical analysis. It includes data analyses for both propensity scores and the multilevel model employed in this study. The final chapter includes a summary, discussion, and suggestions for future research.

CHAPTER 2: LITERATURE REVIEW

Introduction

The purpose of this study was to examine the impact 1:1 computing programs had on schools. The review of literature is divided into three subsections related to how technology has impacted schools. The first section is a review of the history of technology in education over the past 100 years, and common themes are identified. The second section focuses on technology integration in schools, and includes a review of barriers to technology integration as well as recommended solutions to those barriers. The final section focuses on 1:1 programs, and in particular the outcomes that have been found in those programs thus far.

Establishing common definitions

As noted in Chapter 1, a 1:1 school is simply a school that provides a take-home laptop computer for every student within some grade span of the school system. As this study attempted to analyze the impact of this somewhat new movement in education, it is important to look back at the history of technology in education. In doing so, establishing common definitions was essential. Although the terms "technology" and "educational technology" may seem somewhat straightforward, multiple definitions certainly exist. One definition of technology by Merriam-Webster (n.d.) is "the practical application of knowledge especially in a particular area." This broad definition of technology could encompass almost everything in a school. The chalkboard, lights, projectors, and computers all certainly fall under the umbrella of technology. Teachers, administrators, and other staff members also could be defined as technology under this definition in the sense that they are part of the practical application of knowledge.

Unfortunately, this definition is so broad that it fails to adequately focus this literature review.

A more content specific definition is much more appropriate for this study. Various researchers have used the following terms to describe technology in education: visual education, audiovisual instruction, instructional media, instructional technology, educational technology, and instructional design and technology (Anglin (Ed), 2011; Januszewski & Molenda, 2008; Reiser, 2001; Saettler, 2004). The changes in terminology have been influenced by the changes in the uses of technology and the development of the different types of technology that existed. Each of these terms certainly have a history of their own. For the sake of this study, the term educational technology was used along with the definition provided by Januszewski and Molenda (2008) who wrote, “Educational technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate processes and resources” (p. 1). This definition seems to best encompass the early history of technology in education as well as the modern movements in technology in education. It is important to note that this definition took into account both processes and resources. This review of literature focuses on the major technology resources that have been and are currently in use in schools as well as the processes and barriers with implementing those resources.

History of Technology in Education

After reading the definition above, it should become clear how expansive the topic of educational technology truly is. With such a broad topic combined with the extensive history of education, it becomes apparent that a comprehensive review of the topic is not possible in this literature review or any one text for that matter. Instead, this review focused mainly on educational technology from the 20th century as well as technologies from the past decade. It was also restricted to those innovations that have had the largest impact on education. As the various forms of technology are reviewed, there were a couple of common themes that emerged. The first is that all of the technologies were introduced with great excitement and hype as well as an expectation that they would revolutionize education. The second theme was that for the most part the technologies have not revolutionized education in the ways that many imagined, and most did not see the benefits that had been envisioned.

Film: A technology that would transform education

One of the earliest and most exciting technologies of the 20th century was film. The excitement that accompanied film is very clear in a 1922 quote from Thomas Edison cited by Cuban (1986):

> I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. I should say that on the average we get about two percent efficiency out of schoolbooks as they are written today. The education of the future, as I see it, will be conducted through the medium of the motion picture… where it should be possible to obtain one hundred percent efficiency. (p. 9)

Edison’s quote made clear that film was seen as having enormous possibilities in education. The history of film in education is a long one and can be traced back to 1910. At that time, the first trend toward a separation of theatrical and non-theatrical uses was observed (Saettler, 2004). Cuban (1986) wrote that numerous studies in the 1920s and 1930s claimed that films motivated students to learn, but even with that evidence most teachers used film infrequently in their classes fifty years after film was introduced to education. Eventually, film had given way to videocassettes and CDs, but the premise had remained essentially the same. Film had allowed students the opportunity to listen to an "expert" or experience an event or place that they would otherwise be unable to experience. Although penetration of film, or some form of film had been slow, it has finally been fully incorporated into most schools. Walking into a classroom today, one would almost certainly see a television or projector of some type. The National Center for Education Statistics (2010) indicated that nearly 50% of teachers now have an LCD or DLP projector in their room, and that number is certainly growing. Like many forms of technology, the debate about the impact of film on schools persists. Saettler (2004) contended that film has failed to reach its full potential as a medium of instruction and many educators would certainly agree.

Although separate from film, instructional television was another major movement in educational technology. In this review, the two are grouped together because today they have evolved and are non-distinguishable from one another. Instructional television was a major movement during the 1950s, but by the 1960s much of the interest for instructional purposes had disappeared (Reiser, 2001). Cuban (1986) described the three ways in which instructional television was used in the classroom. Total instructional programs, which were extremely rare, occurred when programs were viewed in small or large classes and the teacher simply acted as a supervisor. Supplemental television instruction occurred when a teacher would prepare a class for a video lesson and then follow up the video with an in-class discussion and assignment. The third use was the television as a teaching aide, which would be most common to what teachers do today. Teachers using television in this manner would simply choose when and if to use the television. Classroom television saw widespread growth partially because of the very large financial support from the private sector with the Ford Foundation funding (Reiser, 2001). Eventually, instructional television has become like film and the other technologies discussed in this section. It is simply another tool for educators to use, but it hasn't changed the look of education.

The impact of radio on education

Like film before it, radio moved into the education realm with much excitement from some. Douglas (1987) described the ownership of radio stations as an epidemic, especially with colleges and universities. He went on to describe how many of those stations did not survive long. The School of the Air (SOA) movement was the tool many educators believed would transform education. SOAs were radio stations that offered courses and/or instruction for students through the radio (Bianchi, 2008). The SOA movement, which lasted from approximately 1929 to 1975, reached roughly 10% of the nation's school children and involved many teachers and children directly in radio broadcasting (Bianchi, 2008). SOAs offered a wide variety of courses of study for students at all grade levels (Bianchi, 2008). Cuban (1986) wrote that by the 1950's, television kindled the dreams of another group of educational reformers and research and journal articles on radio in the classroom had virtually disappeared. By the 1980s research on instructional radio ceased, course offerings in radio instruction ended, and commercial networks closed their radio education departments (Saettler, 2004). Like film, radio failed to meet the dreams that many had for it. Radio for educational purposes in K-12 schools in its original form is dead today. With the advent of new technologies that easily incorporate video and images, it seems unlikely that there will be a massive rebirth of educational radio in the classroom.

WWII and the military: A model of using technology for education

World War II certainly played a role in the history of educational technology in this country as well. Because of the war, there was a need to train a massive number of military personnel as well as industrial workers. The challenge was to effectively and efficiently train large numbers of individuals with diverse backgrounds (Reiser, 2001). Because of the intense demands for outcomes along with the extremely high financial resources, technologies were implemented as well as tested and researched (Saettler, 2004). Although the effect of films on the military is unclear, William Kietel, the Chief of German general staff went so far as to claim that the speed at which the film educated American soldiers was a major miscalculation during WWII (Olsen & Bass, 1982). Many researchers claimed that the field of instructional technology began as a result of the research of training devices from World War II (Olsen & Bass, 1982). The post-World War II audiovisual research programs were some of the first to identify principles of learning that could be used in the design of audiovisual materials (Reiser, 2001). The military continues to embrace technology, and many sectors of society benefit from technologies that were first developed and/or used by the military. Their role with technology will most likely remain strong into the future, and that will likely continue to impact technology in education.

Computers: The new tool to revolutionize education

Computers were ushered into education with the hype and excitement of other technologies. Seymour Papert (1984) best demonstrated the enthusiasm and promise that he and many had for computers when he said:

> There won't be schools in the future...I think the computer will blow up the school. That is, the school defined as something where there are classes, teachers running exams, people structured in groups by age, following a curriculum-all of that. The whole system is based on a set of structural concepts that are incompatible with the presence of the computer... But this will happen only in communities of children who have access to computers on a sufficient scale. (p. 38)

This quote is not all that different from predictions made by researchers today. In their book, *Disrupting Class,* Christensen and Johnson (2008) made the claim that by the year 2019, 50% of high school courses will be delivered online. If that claim is accurate, it could drastically transform our schools. However, those predictions aren't all that different from Edison's quote about how film would totally change education. The true question is whether or not computers will be the real game changer that film, radio, and television were not, or if they will simply be the next hyped up piece of technology that never gets fully implemented.

Although many people place the introduction of the computer in schools in the eighties, the history of computers in schools can actually be traced to the late fifties or early sixties. Over the years, several researchers have studied the various roles that computers have played in education. Their views have certainly changed and developed as new computer technologies emerged and roles changed.

In 1982 Taylor and Chonack saw three important roles for computers in education. They saw the computer as a tutor, tool, and/or tutee. The role of tutor referred to computer assisted instruction (CAI) in which the computer teaches the student. The role of the tool was a reference to how the computer could increase a student's ability to address academic tasks. The final potential use of computers was that of tutee which consisted of students learning through programming. These uses were the prevalent ways early computers were used.

Aslan and Reigeluth have identified three major periods of computer use in education (2011). The major periods included the mainframe period that lasted from the late 1950s to late 1970s, the microcomputer period from the late 1970s to the end of the 1990s, and the Internet period from the early 2000s to today. The first two periods they identified are distinct because of the technologies used during the periods. Mainframe and "minicomputers", which were both large and extremely expensive, were used during the mainframe period. Personal and microcomputers, which were much smaller and more affordable, were used during the microcomputer era.

During the mainframe period, the federal government provided large amounts of money to companies in an attempt to research the effectiveness of CAI programs such as TICCIT and PLATO (Saettler, 2004). Most of these CAI programs were simply based on the drill-and-practice model (Saettler, 2004). Even with the support of the federal government, mainframe computers were never widely implemented in schools. Reasons for the lack of infiltration included the extreme cost, limited number of software, difficulty in using software in lesson plans and class, and the minimal experience teachers had using such software (Cosmann, 1996).

In the late 70s, the much smaller microcomputers were introduced in kit form followed by the pre-assembled computers such as the Commodore Pet, Apple, and TRS-80 (Aslan & Reigeluth, 2011). Microcomputers became popular particularly because they were relatively inexpensive, compact enough for desktop use, and they could perform many of the functions performed by the mainframe computers that preceded them (Reiser, 2001). The microcomputer, which is the type of computer we still use today, have seen tremendous growth in use since they were unveiled over thirty years ago. Cuban (1986) reported that in 1984, 68% of schools had at least one computer for an average of one machine for every 92 students. By 2009, the student to computer ratio had become nearly 5:1 (Snyder & Dillow, 2011). The National Center for Educational Statistics (2010) reported that between 1995 and 2008 the average number of computers per school rose from 72 to 189.

Eventual uses for the microcomputer included tutorial CAI, drill and practice, simulations, instructional games, hybrid designs such as problem solving and inquiry, manipulation of text and graphics, programming, computer managed instruction or administrative functions, super calculators, and information processing (Saettler, 2004). Another use of microcomputers today is what Aslan and Reigeluth (2011) considered the third period of technology use, which is the Internet.

The Internet has most likely encouraged the increase in the number of computers in schools, and it has also changed the ways in which computers are used. In 2003 Taylor wrote a follow up to his 1982 book that listed the three important roles for computers as tutor, tool, and/or tutee (Taylor & Chonack, 1982). His 2003 article instead used the verbs access, collaborate, communicate, and experience to describe the current use of digital technology (Taylor, 2003). That is certainly a shift from his 1982 text.

Internet access has also increased drastically in schools in recent years. In 1995 only 8% of instructional rooms had Internet access, but by 2008 that number had increased to 98% (National Center for Educational Statistics, 2010). That same report also reported that the ratio of students to computers with Internet access has also decreased form 6.6:1 to 3.1:1 from 2000 to 2008.

The Internet has almost certainly been the biggest game changer with computers in schools. It has rapidly increased the number of computers in schools because educators saw the power of the Internet. The Internet also changed the types of things that computers were used for at school. The future of computers in schools will undoubtedly be directly related to the Internet.

Online learning: Two powerful findings

Online learning is learning that takes place partially or entirely over the Internet (U.S. Department of Education, 2009). This definition selected for this literature review was intentionally vague, and online learning can look very different in different programs. The literature on this topic, therefore, is also extremely extensive, and it too could have encompassed an entire literature review. Online learning includes totally online courses as well as blended courses. Supplemental instruction as well as tutoring programs are also considered types of online learning. There are also asynchronous and synchronous programs as well as those that blend the two delivery styles. This review did not attempt to address the wide field of literature surrounding this topic, but rather focus on two of the major findings from the studies focused on online learning.

One of the clearest findings around online learning is that it is not likely to go away like many of the other trends in educational technology. When reviewing three large reports published between 2007 and 2011, it became apparent that the growth in online learning has been steep, and it appears that it will continue to grow (Picciano & Seaman, 2007; U.S. Department of Education, 2009; Watson, Murlin, Vashaw, Gemin, Rapp, 2011).

The second finding focused on the impact of online learning. Although there are many studies that are designed to address the successes or failures of online learning, two meta-analysis studies gave a comprehensive overview of what the literature and research on the topic currently indicated. A 2009 U.S. government meta-analysis analyzed a large number of studies relating to online learning (U.S. Department of Education, 2009). The study, which began with database searches that yielded 1,132 articles, eventually included 46 studies that met the rigorous criteria for the study. The findings from the study indicated that classes with online learning, whether completely online or blended, produced stronger learning outcomes than classes with solely face-to-face instruction. A separate study looked at 65 published studies, 18 dissertations, and 13 unpublished studies that analyzed and then compared both wholly online learning and blended learning to face-to-face classroom instruction (Sitzmann, Kraiger, Stewart, & Wisher, 2006). The study found that totally online instruction was 6% more effective at teaching declarative knowledge than classroom instruction and blended instruction was 13% more effective than classroom instruction. The study also looked at procedural knowledge and found no difference between total online instruction and classroom instruction, but it did indicate blended instruction was 20% more effective.

These studies as well as the trends in the number of online programs indicated that online learning is one technology that is almost certainly here to stay. As rural and even urban schools fight to provide robust curricula for their students, online learning will almost certainly be part of that conversation. However, like most technologies, online learning may look very different in various locations. For this reason, the success and failure of online learning programs may be very dissimilar in different programs.

Overarching themes of technology in education

When reflecting on the growth of technology in schools, it is easy to become complacent about the progress that has been made. Each of the aforementioned technologies entered education with a great deal of hype and excitement. Like Edison's quote about film, similar statements were made for all of these technologies. Most would agree however, that technologies have failed to greatly change education. Many critics still believe that education is lagging substantially when it comes to technology use. A report from the U.S. Department of Commerce (2003) ranked education as the lowest technology intensive enterprise of the 55 U.S. industry sectors that were ranked. When reviewing the history of technology in education above, many common problems were observed. Most technologies were introduced with great excitement, but they failed to ever get fully implemented or drastically change education. Many of those barriers to successful implementation are discussed in the next section of this study.

Technology Integration

The current study partially focused on how technology was integrated in 1:1 schools as opposed to non-1:1 schools. Many educators have differing views on what technology integration is and what it looks like. Earle (2002) wrote that “Integrating technology is not about technology - it is primarily about content and effective instructional practices” (p. 7). Other definitions vary, but most viewed integration as a way to use technology to enhance learning: “Technology integration is having the curriculum drive technology usage, not having technology drive the curriculum” (Dockstader, 1999, p. 73).

Snider (1992) highlighted the history of the excitement and the results we have seen with technology in the last 90 years:

> From lantern slides to language labs, from closed-circuit television to microcomputers, attempts to improve American schools with modern machines have been something less than a resounding success. Beginning with the magic lantern and the stereoscope of 1900, machines in the classroom have generated some promise, a fair amount of controversy, and a great deal of hype. During these 90-plus years, however, the basic acts of classroom teaching have changed very little despite sporadic efforts at research and reform - with and without machines. (p. 316)

In the previous section, a definition by Januszewski and Molenda (2008) was used to explain educational technology. That definition, like most in the literature, incorporated both teaching and learning into the definition. Unfortunately, the prevailing public perception simply sees instructional technology as a synonym for computer technology (Earle, 2002). Earle went on to note that such a misunderstanding has been part of the problem with technology integration because the focus has been on access to hardware as opposed to pedagogy. Even as the amount of technology in schools has increased drastically in recent years, true integration of technology has lagged. Many school leaders and policymakers have focused their conversations on the technology itself rather than also focusing on ways the technology can be used to transform schools. This disconnect has greatly impacted how technology has been integrated in schools.

Barriers to integration

Even though technology availability has increased drastically in recent years, high-level technology use is still surprisingly low (Ertmer, 2005). There have been numerous things that have been identified as barriers to successful technology implementation in schools. Those barriers can be identified as either first-order barriers, which are obstacles that are external to teachers or second-order barriers, which are intrinsic to teachers (Ertmer, 1999). This section investigated both types of barriers as they have had serious implications for the successful integration of technology in any school setting.

One of the largest barriers to integrating technology in education is there simply has not been an emphasis on teaching and learning when new technology was introduced. Hennessy, Ruthven, and Brindley (2005) wrote that the increased investment in technology infrastructure has not been matched by an investment in developing new ways of learning and teaching. Teachers have routinely been given technology with minimal training. True change has also been slowed because many of the technology initiatives have been top down policy initiatives. Teachers have not had input in the decision-making, and haven't fully understood or supported the change. Not taking into account teachers' theories about teaching and learning, and the lack of input greatly hinders integration (Mumtaz, 2000).

The context in which teachers work can also be a major influence on technology integration. The teams that teachers work with, and the culture of those teams can have great influence on their technology integration (Hennessy, Ruthven, and Brindley, 2005). Other authors claim that the subject area in which a teacher teaches has an impact on how technology is used. Andrews (as cited by Hennessy, Ruthven, and Brindley, 2005) reported that the "book-dominated" culture of English is a factor in resistance of English teachers to use of new technologies. Selwyn (1999) contended that math and science departments embraced the use of technologies more than other areas because those subjects have been the traditional domains for computers.

Personal factors associated with higher levels of computer use also played a role in how technology was integrated. Becker (as cited in Hennessy, Ruthven, and Brindley, 2005) reported teacher traits such as openness to change and recognition of transformative potential of using technology affected how technology was integrated in their classrooms. There were three other significant factors that were found among teachers who were more likely to give tasks using computer work to students. First, teachers whose pedagogy focused on a small number of topics covered in great depth were twice as likely to assign computer activities. Secondly, teachers with five to eight computers in their classrooms compared to teachers with limited access to computer labs were twice as likely to provide students with frequent computer experiences. Finally, teachers who had greater technical knowledge used computers more (Becker, 2000). Ponticell (2003) wrote, "conservative teacher and school cultures can make changing classroom and school practices risky" (p 19). Straub (2009), who viewed technology adoption through three adoption theories, stressed that successful facilitation of technology adoption must address cognitive, emotional, and contextual concerns. These concerns are often not addressed by school leaders. Barriers reported by Ertmer and Ottenbreit-Leftwich (2010) included lack of relevant knowledge, low self-efficacy, existing belief systems, and the context in which teachers work. In general, schools fail to identify and deal with these concerns.

Lack of resources was another significant barrier for schools and teachers. Lack of resources may be due to a lack of technology, access to available technology, time, and technical support (Hew & Brush, 2006). Bauer and Kenton (2005) found that lack of equipment was the number one obstacle teachers reported having to overcome. Obviously, teachers who lack access to technology are unable to integrate technology into their curriculum. A challenge for schools is to provide their teachers with resources as well as training.

One of the most comprehensive reviews of the literature on the barriers of technology integration was conducted by Hew and Brush in 2006. Their study reviewed research between 1995 and the spring of 2006 and they found 123 different barriers in the research. They were then able to classify those barriers into six main categories: (a) resources, (b) knowledge and skills, (c) institution, (d) attitudes and beliefs, (e) assessment, and (f) subject culture. These categories are listed in the order by the frequency with which they were found. Each of the barriers listed above would fall into one or more of their categories. Hew and Brush (2006) go beyond simply looking at the studies on the barriers; they also reviewed strategies to overcome those barriers. The next section of this paper focuses on some of those ways schools have been able to effectively integrate technology.

Effective integration

As schools invest large amounts of resources into technology, they want to ensure that the technology is used in ways that benefit students. Unfortunately, a large amount of technology isn't used in ways that enhance student learning. Even in many classrooms where technology is used, it isn't being used in the ways that most benefit students. Although research emphasizes technology use that supports inquiry, collaboration, and reformed practice, many teachers tend to use technology for presentation software, learner-friendly Web sites, and management tools to enhance existing practice (Harris, Mishra, and Koehler, 2009). Professional development was also of interest in this study because it has been found to have a direct impact on the success of a 1:1 program (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Shapley et. al., 2010). This section is a review of the literature pertaining to how to overcome the many obstacles to technology integration as well as a particular focus on professional development.

One model for facilitating effective technology integration is the TPACK model, which referred to a combination of technology (T), pedagogy (P), and content (C) knowledge (K) (Harris, Mishra, & Koehler, 2009). The TPACK model stressed not only the importance of understanding each of the three components but also the significance of understanding the relationships and interactions between the components. This overlap is often a weakness for many educators. They may possess appropriate content or pedagogy knowledge, but they don't have an understanding of technology. With that lack of technology knowledge, they are unable to intertwine technology with their content and the pedagogy that they use. Helping teachers gain a basic understanding of technology may be an appropriate way to help teachers integrate technology. In order to help teachers gain basic skills, teachers need research-based training, opportunities to practice skills, access to technology tools, and support from leadership (Dawson & Rakes, 2003). This finding isn't surprising, yet schools often fail to provide teachers with basic training about the technology tools they are expected to use.

There have been other studies that have found interesting results in regard to technology use in classrooms. One study indicated that there is a strong positive relationship between teachers use of technology in the classroom and the constructivist practices in the classroom (Rakes, Fields, & Cox, 2006). School leaders should take this into consideration when creating professional development. Encouraging and providing resources to develop a more constructivist approach may help teachers use technology in more meaningful ways. It may also help them genuinely change the ways that they think about teaching and learning.

Cennamo, Ross and Ertmer (as cited by Ertmer and Ottenbreit-Leftwich, 2010) wrote that in order for teacher to achieve technology integration that targets student learning, teachers needed knowledge that allows them to:

- Identify the technologies needed to support curricular goals
- Clearly state how the tools will be used to help students meet and demonstrate those goals
- Allow students to use applicable technologies in all phases of the learning process

- Select and use the appropriate technologies related to their own professional development areas. (as cited by Ertmer and Ottenbreit-Leftwich, 2010)

Helping develop a high self-efficacy with technology for teachers may also be a powerful way to help them implement technology in their classrooms (Bauer & Kenton, 2005; Ertmer & Ottenbreit-Leftwich, 2010). Although this research is certainly interesting, it leads to the question as to how self-efficacy can be improved. Ertmer & Ottenbreit-Leftwich (2010) identified numerous ways the literature revealed self-efficacy could be increased. Those strategies included:

- Giving teachers time to play and explore technology
- Focusing new uses on immediate needs
- Starting with small successful experiences to enhance confidence
- Time working with peers who are knowledgeable about technology
- Providing access to suitable models who use technology appropriately
- Participating in a professional learning community
- Designing professional development programs that are within the context of teachers' ongoing work (p. 261-262)

Professional development can be seen as one of the most important components for any initiative, and technology is not unique. Unfortunately, in a review of the literature on technology professional development, Lawless and Pellegrino (2007), argued that overall the research is very weak.

Ertmer & Ottenbreit-Leftwich (2010) stressed the importance that professional development programs include information about how new tools can be used in very specific ways, within specific content areas. This finding aligned with the TPACK model.

Professional development should be designed in ways that allow teachers to learn about technology use in their specific content areas.

A review of literature by Hew and Brush (2006) found three significant factors for effective professional development related to technology integration. The first factor identified was a focus on content. This is sometimes a controversial topic when leading professional development, as many educators believe professional development shouldn't focus on technology skills, but rather integrating technology into training. Their review however reinforced the idea that teachers must have some basic knowledge about technology in order to effectively use it in their classroom. Snoeyink and Ertmer found that teachers did not see the value of technology integration until they had developed basic technology skills (as cited in Hew & Brush, 2006). The second factor in successful professional development was to give teachers opportunities for hands-on work. This factor certainly isn't unique to technology, and is a strategy embraced by many educational leaders. The final component they identified was that professional development had to be highly consistent with teacher needs.

When schools move to a technology rich environment, it is natural to want and expect major changes quickly. However, implementing change incrementally may be a more effective way to ensure true change. Ertmer (2005) noted that when technology is involved, beginning with relatively simple uses may be a more productive way to change teacher behaviors than expecting teachers to use technology to achieve high-end instructional goals immediately. Too often, the tension that teachers feel with any new initiative can take away from the success of that initiative. If teachers and school leaders understand that radical change may not be immediate, the long -term benefits may increase.

Professional learning communities (PLCs) have been a hot issue in education recently with many suggesting the power of PLCs for any organization. Technology initiatives are no different. In order to continue to improve technology use, developing professional learning communities (PLCs) around technology may be effective (Ertmer, 2005). The concept of building support teams certainly isn't unique to technology, and many schools have embraced PLCs as an effective way to move initiatives forward. Hughes, Kerr, and Ooms (2005) recommend that schools establish technology inquiry groups, which are a particular type of PLC. PLCs also align with many of the suggestions from above. Developing content specific PLCs may help teachers learn to use technologies that are most appropriate for their content area. Through the lens of the TPACK framework, PLCs can be a very effective way to address each of the three main components of TPACK.

Schools today are spending a great deal of money on technology in their schools. Unfortunately, even as new technologies make their way into the classroom, little is changing. Some technology simply goes unused, and other technology is not used to its fullest potential. This section described many of the barriers to successful technology integration as well as ways to avoid those barriers.

1:1 Programs in Education

The focus of this study has been to analyze the impact that 1:1 schools have had on various components of education. Unfortunately, the current research on this topic has some limitations. Although forms of 1:1 programs existed over twenty years ago

(Dwyer, 1994), many educators still see 1:1 schools as a somewhat new phenomenon. The amount and type of research on the topic has also lagged. Much of the research that does exist comes from state reports or technology corporations that have a vested interest in 1:1 programs. Even the research that is a bit more academic tends to have very small sample sizes. A recent special edition of the *Journal of Technology, Learning, and Assessment* (JTLA) exemplified this point. The special edition noted little published research has occurred around 1:1 initiatives, and their journal was designed to help fill that void (Bebell & O'Dwyer, 2010). Some may see the JTLA special edition as a clear example of how little research exists. Only six articles were published in the special edition, and two of those were literature reviews. The four remaining studies only analyzed a total of 33 1:1 schools. The largest one studied 21 1:1 Texas schools and the others studies' sample sizes were three, four, and five 1:1 schools (Bebell & Kay, 2010; Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Shapley et al., 2010; Suhr, Hernandez, Grimes, Warschauer, 2010). The need for larger studies that involve more schools is very clear. Stroud found that 67% of 1:1 studies focused on the time from pre-implementation and the first two years of implementation (as cited in Drayton et al., 2010). The present study did not include schools that were in their first year of implementation because much of the literature has revealed greater results have been found after the initial year. The majority of 1:1 schools in this study will be in year two of implementation.

In all likelihood, the earliest 1:1 program was the Apple Classrooms of Tomorrow project that began in 1986 and actually provided students and teachers with two computers (Dwyer, 1994). The reason for multiple computers was simply that at that time computers were too large and bulky to be easily transported. Even with what many today would view as very primitive computer technology, Dwyer (1994) reported numerous benefits from the program for both students and teachers. Student benefits included higher scores on achievement tests, increased writing and more effective writing, increased productivity, more collaboration, more project based instruction, decreased absenteeism (by almost half), and better organization. Teacher changes included: changing the forms of interactions between students and between students and teachers, engaging students in higher order cognitive tasks, and questioning of old assumptions about instruction and learning. The results from this initial program were very promising.

Since that initial program, many more schools have become 1:1 schools. That first program found numerous benefits, but various results have been reported by other 1:1 programs, and that impact is constantly up for debate. Some schools have gone so far as to cancel their programs because of lack of evidence of improvements and many wonder about the impact of 1:1 programs (Bain & Weston, 2009; Hu, 2007). Policymakers want to know if becoming a 1:1 school is worth the investment and if it truly changes their school. Weston and Bain (2010) have argued that 1:1 laptop initiatives may go further than almost any other efforts to change schools. Part of the concern with 1:1 schools may be that there doesn’t seem to be one common “result” of the initiative. The discrepancy in results may be do to that fact that the term “1:1” simply refers to access students have to technology, and it says nothing about pedagogical changes, learning outcomes, or other educational practices (Bebell & O’Dwyer, 2010). Peunuel (2006) claimed that most schools have focused on one of four outcomes when implementing a one-to-one program. Those goals included improved academic achievement, increased equity, increased economic competitiveness of a region, and/or transforming the quality of instruction. The major benefits in the remainder of this section focused on academic achievement, non-academic student outcomes, and teaching behaviors. Although each of these sections are described separately, it is evident that each of the areas are interrelated.

Academic achievement

Academic results of 1:1 programs have been reported in nearly every academic content area. Of the core content areas, the most frequent and most substantial reports have been reported in writing. Maine, which implemented 1:1 statewide in their middle schools in 2002, has seen significant improvements in their writing scores on statewide tests (Silvernail & Gritter, 2007). Other studies have also reported the positive impacts of 1:1 programs on writing (Bebell & Kay, 2010; Gulek & Demirtas, 2005; Lowther, Ross, and Morrison, 2003). With the relationship between writing skills and literacy, it isn't surprising that others have also reported improvements in both writing and literacy skills (Suhr, Hernandez, Grimes, & Warschauer, 2010).

The research on the impact in the areas of math and science is a bit more limited. A study by Dunleavy & Heineck (2008) found that middle school students in a 1:1 program saw a significant increase in its science achievement test when compared with non-laptop peers. Shapley et al. (2006) indicated that the strength of a students' access and use of technology was a consistent positive predictor of a students' reading and math scores, and students' use of their laptop at home was the strongest implementation predictor of reading and math state achievement scores. Other researchers have found that greater access to technology can enhance science education at both the middle and high school-levels (Berry & Wintle, 2009; Siegle & Foster, 2000).

Other studies have looked at GPAs as performance indicators. Lei & Zhao (2008) reported marginally significant increases in average student GPA when comparing a group of middle school student GPAs longitudinally. A separate study found that after two years in a laptop program, students scored significantly better than their peers in all subject areas (Light, McDermott, & Honey, 2002).

Non-academic results

Although many critics of 1:1 programs worry about the distractions that will be created with laptops, numerous studies have indicated that student engagement increases in a 1:1 setting (Bebell, 2005; Metiri Group, 2006; Mouza, 2008; Russell, Bebell, & Higgins, 2004; Warschauer & Grimes, 2005; Zucker & McGhee, 2005). Bebell and Kay (2010) studied the impact of 1:1 initiatives on five Massachusetts middle schols and reported that teacher surveys indicated that student engagement and motivation increased in the 1:1 setting. A study of 44 Texas middle schools reported significant improvements on two major indicators of student engagement (Shapley, et al., 2006). Interviews with 1:1 educators in Indiana revealed numerous benefits of their 1:1 program (Lemke & Martin, 2004b). Those benefits included increased student and teacher engagement, improved attendance, improved academic achievement, deeper cross-disciplinary knowledge, and more in depth 21st century skills development. A state report from Michigan reported similar results including increased student engagement, improved attendance, and increased 21st century skills development (Lemke & Martin, 2004a). As well as seeing a positive impact on writing scores, Lowther, Ross, and Morrison (2003) also reported improvements in problem solving.

Impact on teaching

A study on the impact of 1:1 initiatives in Florida, which were aimed at changing teaching practices, also revealed some powerful results (Dawson, Cavanaugh, & Ritzhaupt, 2006). The study of 447 classrooms reported an increase in high student attention, interest, and engagement and a decrease in the use of traditional independent seatwork. Other changes included greater use of: project based learning, teachers acting as coach/facilitator, cooperative/collaborative learning, indendent inquiry research, and high academic focused class time, with a decline in direct instruction. After observing 1:1 programs for over 10 years, Rockman (2003) found that teachers in 1:1 schools lectured less and there was more individual and group project work. Other researchers also observed increases in teacher collaboration in the 1:1 setting (Burns & Polman, 2006).

Although the research on 1:1 schools is limited, positive results have been found in a variety of different areas. The research above found positive results for both students and teachers. Much more research on 1:1 schools needs to happen in order to get a clearer picture of how the programs are impacting schools. This study hopes to add to that body of research.

Summary

The literature outlined in this chapter as well as the framework in Chapter 1 were used to select the methods that will be described in the next chapter. The history of technology in education described in this chapter identified the challenges and slow speed with which technology has filtered into our schools. Even once more resources were available, they typically haven't been integrated into classrooms very well. Using Rogers' model (2003), most of these initiatives would fall into the rejection area in the confirmation stage of the innovation-decision process. This review also highlighted how the research on 1:1 schools is also very limited and disjointed. All of those factors were reasons for designing this study. Policymakers need to be able to make informed decisions about 1:1 program implementation and the impact it could have in their schools. The history of technology in education may indicate that technology has not lived up to its hype, and educators need to know if 1:1 programs are on that same path. This study strived to help contribute to the literature around the impact of technology in education.

CHAPTER 3: METHODOLOGY

Overview

The purpose of this study was to examine the impact 1:1 computing has had on schools. This chapter communicates the methods that were employed to answer the multiple research questions. The chapter includes sections about the research questions, research design, setting, population, data collection methods, study variables, data analysis, limitations and ethical issues.

Research Questions

The following questions were the main areas of focus for this study. The tools described in this chapter as well as the methodologies used were selected because they appeared to be the most effective, plausible techniques to answer these questions.

1. Do teachers at 1:1 schools report that their students use technology *more frequently* than teachers at non-1:1 schools?
2. Do teachers at 1:1 schools report that they *integrate* technology differently than teachers at non-1:1 schools?
3. Do teachers at 1:1 schools report higher levels of *technology competency* than teachers at non-1:1 schools?

It would seem apparent that teachers at 1:1 schools would use technology much more substantially than those at non-1:1 schools. However, some recent research indicated that the amount of time spent using technology at many 1:1 schools is actually quite minimal (Project Red, 2010). As policymakers make decisions about moving to a 1:1 program, they want to know if and how much more students are using technology.

Historically, access to technology hasn't always resulted in substantial increases in the amount of time students are using technology. The second research question may be the most important question in this study. Many educators want to know *how* technology use at 1:1 schools looks different than at non-1:1 schools. Research question two addresses whether or not technology integration is different at 1:1 schools. Both of these questions can serve as ways to analyze whether or not technology had become a regular part of the school environment. The final research question assesses the technology proficiency level of teachers. This is important when reflecting on the TPACK framework that was previously introduced. That model addresses the importance of technology, pedagogy, and content knowledge, and the overlap of the three when using technology to enhance instruction. This research question addresses technology knowledge which is one of those three components. Building off that framework, it can be hypothesized that increased competency would result in higher levels of integration.

Research Design and Methodology

This study was designed to determine if a school's 1:1 status impacted time students use technology, teacher integration with technology, and teacher competency with technology, after controlling for other school and teacher characteristics. The research design for this study consisted of two major components. Initially, propensity scores were used in order to minimize bias in the sample that could occur because 1:1 schools are self-selected. Propensity scores identified treatment and control schools that were similar to one another on multiple characteristics. Once the sample was identified, a multilevel model was used to account for the unique make-up of the data in this study. The study took both school and individual teacher characteristics into account. That model provided an analysis of the impact of 1:1 initiatives on the various research questions.

Propensity score matching

The ideal research design for nearly any experiment would be a random experiment. In a random experiment, the randomization of units guarantees that on average there should be no systematic differences in observed or unobserved covariates between units assigned to different treatments (D'Agostino, 1998). When a random experiment is not an option, it is important to find a tool that will attempt to produce similar results to what would be observed in a random experiment. In this study, propensity scores helped the research design more closely resemble a random experiment than many other models. Rosenbaum and Rubin (1983) defined the propensity score as "the conditional probability of assignment to a particular treatment given a vector of observed covariates" (p. 41).

In a perfect experiment, the control and treatment groups look identical in all possible ways. If the goal of the research is to determine the impact of a treatment on a group, the researcher can simply apply the treatment to one group and then compare the results from the control group to the treatment group. Any difference between the groups can be assumed to be due to the treatment since all other characteristics of the groups should be nearly identical. That experiment could be represented by the following formula, which simply identifies the difference between the treatment and control groups:

Treatment – Control = Treatment Effect

Another way to consider a superior research design is to think about how a perfect observational research model would be designed. If researchers were concerned about the impact of treatment X on school Y, comparing school Y to itself would be ideal. The term counterfactual is used to describe this thought experiment and this term stems from the Neyman-Rubin counterfactual framework of causality (Guo & Fraser, 2010). A counterfactual is the hypothetical result of what would have happened to school Y had it not participated in the treatment. The treatment effect could be written as:

Treatment Y - Control Y = Treatment Effect

In this hypothetical model, a researcher considers what would have happened to an individual in a treatment group had they not been in the treatment group. Essentially, this would be a perfect research design because the study would actually compare a treatment individual to that same individual as a control. There would certainly be no variation in variables or omitted variable bias in this research design. Obviously, this model is not an option, but it does help explain the rationale behind propensity scores.

The schools that are part of the treatment group (1:1) in this study have self-selected to take part in the treatment. This can cause serious problems for researchers. Unlike the groups from the random or counterfactual experiments, it is almost certain that the 1:1 schools in the study are different in some ways from other schools. Comparing the 1:1 schools in Iowa to all other non-1:1 schools could result in false assumptions. In the most simplistic way, that design would compare "apples to oranges." The results can also be very misleading because what was found to be the impact of the treatment could actually be due to other unmeasured variables.

The goal of this study was to answer the research questions, which seek to find the impact that 1:1 status has had based on teacher responses. Because a random sample was not possible, propensity scores were used to match treatment and control schools. Essentially, propensity scores seek to create a counterfactual school for each treatment school. Simply put, the study tried to compare treatment and control schools that looked very similar to one another. The steps for generating and applying propensity scores are introduced below, and described in more detail in the following sections:

1. Variables used to generate propensity scores were identified.
2. Variables were plugged into a logistic regression model in order to generate propensity scores for each school.
3. Control (non-1:1) and treatment (1:1) schools were matched to one another.
4. Post-matching analysis of variables used to create the propensity scores took place.

Identify propensity score variables.

Shadish and Steiner (2010) claimed that the most important factor in the successful use of propensity score analysis was the quality of the measures used to create the propensity scores. The covariates that are selected should in some way be related to the treatment, and there should be an imbalance between the treatment and control groups on these covariates (Fan & Nowell, 2011). If there is no imbalance between the scores, there is no need to use propensity score matching (PSM) simply because the groups already look similar with the covariates being used. Theoretically, it would be most effective to identify those variables that can be associated with 1:1 status and use those variables to generate propensity scores. Unfortunately, there is not a body of literature that examines the reasons schools choose to implement a 1:1 program. Because of the lack of literature, variables were identified in other ways. First, data were collected on approximately 150 school-level variables. Those variables that contained large amounts of missing data were removed from the model. Once data collection was complete, t-tests were run to identify the group differences between 1:1 schools and non-1:1 schools. The t-test is a very basic statistical test that analyzes significant differences between two group means (Mertler & VAnnatta, 2010). The t-test identified all of the variables that had statistically significant differences in means. Those variables were then analyzed using a correlation matrix. The correlation matrix was used so variables that were highly correlated with one another could be identified. Rubin and Thomas (1996) cautioned against including variables in propensity score matching that were highly correlated with one another. After identifying the variables with high correlations, a determination was made about which variables to exclude.

Once variables had been analyzed with the t-test and a correlation matrix, a determination had to be made about which variables to include in the study. Those variables that had statistically significant values on the t-test, and seemed to potentially be related to the decision to become a 1:1 school were included in the final model. Table 4 includes t-test results, and 11 variables were identified as statistically significant. Other variables that were not statistically significant were also included in the model if it appeared that they might have had a relationship with the outcome variable. Although the inclination may be to remove those variables, they should remain in the model unless it is clear that they are unrelated to the outcome variable (Rubin & Thomas, 1996). This study selected variables for the propensity score model that may have potentially been related to a school choosing to implement a 1:1 initiative. Those variables that were selected could be divided into four interconnected categories. The first category includes variables that describe the school, such as enrollment and student to teacher ratio. These variables were included because it is very possible certain types of schools are more likely to become 1:1 schools. The second category included those variables that described the students that attended a particular school, such as percentage of students proficient in math. These variables were selected because schools with certain types of student populations may be more likely to make the decision to become a 1:1 school. The next category consisted of variables that included details about the staff members at each school. Because staff members often have input into the decision to implement a 1:1 initiative, these variables were an important group to include. Two variables in this group that had means that were very different between 1:1 schools and non-1:1 schools were the leadership variables. Principals at 1:1 schools were younger than those at non-1:1 schools and superintendents from 1:1 districts had less experience in the district than their non-1:1 peers. The superintendent district experience difference in means may relate to the fact that superintendents new to a district are more likely to engage in a major change initiative. The final category of variables included in the propensity score matching was community variables. Those variables included median family income and percent of the population with a college degree. These variables were included because it is quite possible that a certain type of community is more likely to embrace a 1:1 program. This category included five variables that had statistically significant differences in means between the 1:1 and non-1:1 schools. It appears that those community variables have a large impact on whether or not a school becomes a 1:1 school. Each of these categories may certainly have played a role in a school's decision to implement a 1:1 initiative. Although the role of each variable is not known with certainty, the literature suggests that it better to keep the variables in the model rather than to simply remove them (Rubin & Thomas, 1996).

A list of the 22 final variables used to generate propensity scores can be found in Table A1 in Appendix A. The appendix also contains descriptive information about each of those variables as well as the data source for each variable.

Once variables for propensity score matching had been identified, it was important to analyze the variables for multicollinearity. Mertler and Vannatta (2010) define multicollinearity as the problem when independent variables are very highly correlated with one another. In order to check for multicollinearity between the variables, correlation and variance inflation factor (VIF) scores were analyzed. VIF scores indicate if a given independent variable has a strong linear relationship between it and the other remaining variables (Stevens, 2001). A correlation matrix was run with Stata to identify the correlations among all 22 variables from the model. That matrix was created using the values from all 269 schools in the study population. Although there isn't one reported acceptable level for correlation, correlations greater than .70-.80 are generally signs of multicollinearity between variables (Slinker and Stanton, 1985). The correlation matrix is displayed in Table 1, and it is worth noting that only 12 values were greater than .50 and none of the variables were above .80.

After running the correlation matrix, VIF scores were generated using Stata. The VIF values ranged from 1.29 to 5.34 and the mean VIF score was 2.50, which are all acceptable rates. Although there isn't one recognized acceptable level of VIF scores, Stevens (2001) noted that VIF scores greater than 10 are usually problematic. Table 2 reports the results of the VIF analysis. The multiple tests used in this section seem to indicate that the variables do not have multicollinearity.

Table 1

Correlation Matrix for Propensity Score Variables

		1	2	3	4	5	6	7	8	9	10	11
1	School Enrollment	1.00										
2	% Prof. 11th Math	-0.16	1.00									
3	% Prof. 11th Reading	-0.02	0.71	1.00								
4	% Female	0.05	-0.02	-0.03	1.00							
5	% Nonwhite	0.53	-0.35	-0.29	-0.03	1.00						
6	% Free and Reduced	0.10	-0.47	-0.39	-0.02	0.46	1.00					
7	Student to Teacher Ratio	0.06	-0.01	0.03	-0.01	0.01	-0.05	1.00				
8	% ELL	0.24	-0.28	-0.24	0.00	0.73	0.36	-0.01	1.00			
9	% IEP	0.14	-0.30	-0.18	0.06	0.15	0.50	-0.03	0.02	1.00		
10	Local Revenue	-0.13	0.37	0.29	-0.02	-0.28	-0.42	-0.05	-0.29	-0.45	1.00	
11	% Discipline Occurrences	0.40	-0.33	-0.25	0.00	0.55	0.36	0.03	0.27	0.28	-0.30	1.00
12	Students per Computer	0.38	-0.13	-0.11	0.03	0.34	0.05	0.11	0.24	0.02	-0.21	0.17
13	Graduation Rate	-0.59	0.40	0.28	-0.09	-0.63	-0.48	-0.07	-0.36	-0.37	0.37	-0.49
14	Teacher Avg. Age	-0.06	-0.06	0.01	-0.03	0.01	0.19	0.07	0.04	0.19	-0.16	0.03
15	Teacher District Experience	-0.19	0.11	0.10	-0.02	-0.17	-0.02	0.04	-0.11	0.06	-0.05	-0.12
16	Principal District Experience	0.20	-0.07	0.02	-0.07	0.10	0.11	0.03	0.06	0.01	-0.16	-0.02
17	Age of Principal	0.11	-0.05	0.02	-0.04	0.05	0.09	-0.02	-0.02	0.17	-0.09	0.07
18	Superintendent District Experience	-0.07	0.12	0.17	0.06	-0.12	-0.05	-0.02	-0.08	-0.10	0.01	-0.09
19	Rural	-0.59	0.16	0.11	-0.01	-0.43	-0.15	-0.02	-0.26	-0.15	0.18	-0.30
20	% over 25 with College Degree	0.54	0.22	0.28	-0.01	0.21	-0.39	0.02	0.04	-0.30	0.35	-0.04
21	% over 16 in Labor Force	0.22	0.24	0.20	-0.06	-0.02	-0.50	0.07	-0.05	-0.33	0.27	-0.14
22	Medium Family Income	0.37	0.26	0.24	-0.01	0.01	-0.59	0.09	-0.08	-0.44	0.36	-0.11

Table 1 (Continued)

Correlation Matrix for Propensity Score Variables

		12	13	14	15	16	17	18	19	20	21	22
12	Students per Computer	1.00										
13	Graduation Rate	-0.32	1.00									
14	Teacher Avg. Age	-0.09	-0.14	1.00								
15	Teacher District Experience	-0.15	0.03	0.78	1.00							
16	Principal District Experience	-0.02	-0.11	0.05	0.06	1.00						
17	Age of Principal	-0.02	-0.12	0.09	0.01	0.49	1.00					
18	Superintendent District Experience	-0.13	0.10	-0.10	-0.02	0.21	0.06	1.00				
19	Rural	-0.14	0.46	-0.08	0.07	-0.19	-0.14	0.03	1.00			
20	% over 25 with College Degree	0.20	-0.04	-0.20	-0.26	0.03	0.06	0.02	-0.31	1.00		
21	% over 16 in Labor Force	0.25	0.11	-0.38	-0.30	-0.03	-0.01	-0.03	0.03	0.49	1.00	
22	Medium Family Income	0.24	0.10	-0.41	-0.34	0.01	0.00	0.00	-0.09	0.75	0.74	1.00

Table 2

Variance Inflation Scores

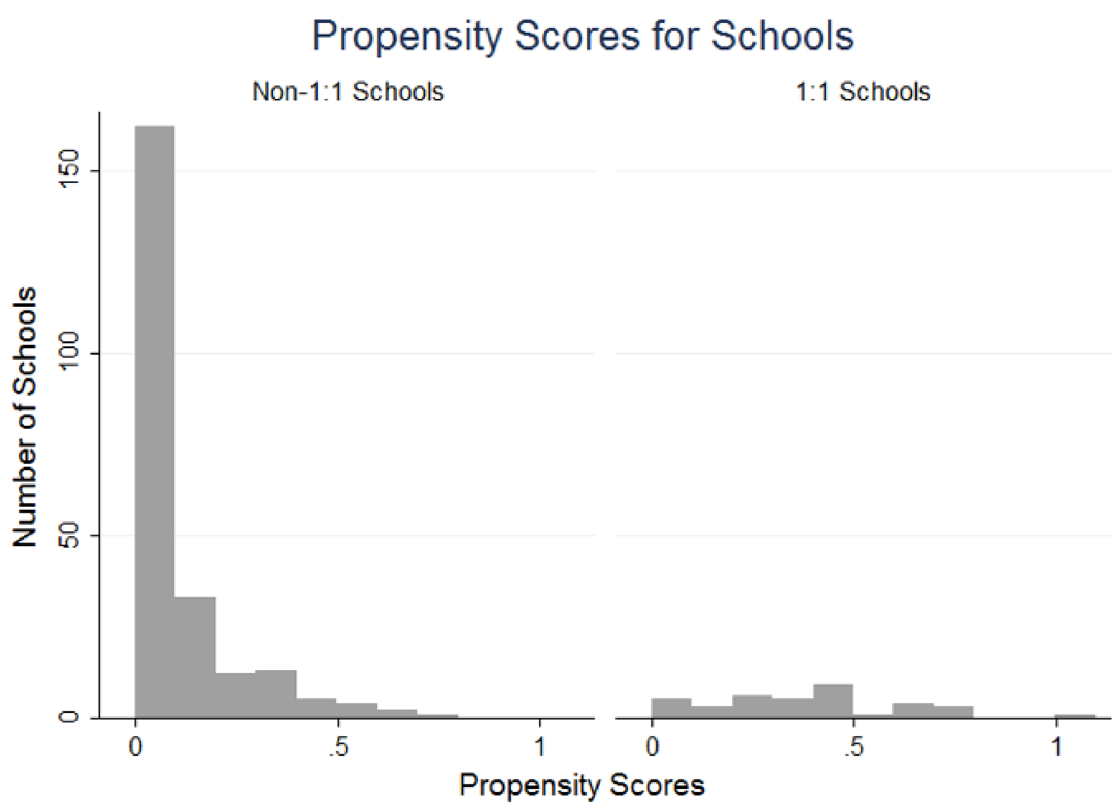
	VIF Score
School Enrollment	3.63
% proficient 11th math	2.48
% proficient 11th reading	2.3
% female	1.06
% nonwhite	4.91
% free and reduced lunch	3.03
Student to teacher ratio	1.05
% ELL	2.63
% IEP	1.86
Total revenue: local % to total %	1.79
% of total removals (all types)	1.85
Students per computer	1.41
Graduation rate	2.77
Age of teachers	3.31
Teacher district experience	3.26
Principal district experience	1.65
Age of principal	1.45
Superintendent district experience	1.16
Rural	1.78
Percent >25 with college degree	3.93
Percent >16 in labor force	2.47
Medium Family Income	5.34
Mean VIF	2.5

It is also important to note that the variables used for this study were from the 2007-2008 school year. The reason for using historical data relates to the nature of propensity score matching (PSM). A study by Schudde (2011) highlights the need for using historical data. When studying the causal effect of campus residency on student retention, Schudde (2011) created a model that identified students who had a similar propensity to live on campus prior to arriving, but who made different housing choices. In Schudde's model, he used variables prior to students' arrival on campus because the more current variables could have been related to their campus residency. The model for this study took the same approach because variables from the current year could be impacted by whether or not a school implemented a 1:1 program. Things like attendance, graduation rate, or achievement potentially may be impacted by a school's 1:1 status. Therefore, variables for the PSM portion of this study were collected from the year prior to 1:1 implementation.

Determine probabilities (propensity scores).

Once propensity score variables were identified, propensity scores were generated for every school. These scores were generated by using a logistic regression model that produced the probability (propensity score) of being in the treatment for each school. A schools' propensity for being a 1:1 school could be generated by including 1:1 status as the dependent variable, and the other 22 variables as the independent variables. The logistic regression model that included the 22 variables for the model produced a probability score for each of the 269 schools in the model. A higher score indicated a school either was a 1:1 school, or looked similar to the 1:1 schools. If there was not a difference in the group means, there would not be a reason to continue with the matching because the 1:1 and non-1:1 schools would be very similar to one another. However, a t-test on the propensity scores indicated that there was a statistically significant difference between 1:1 and non-1:1 schools ($p < .001$). The mean propensity score value for 1:1 schools was .39 and .10 for non-1:1 schools. This difference in mean highlights the differences between the two groups. The histogram in Figure 1 displays the propensity scores for the 1:1 and non-1:1 schools. Those schools at the extreme end of the non-1:1 histogram were eventually removed from this study. The matching process is described in more detail in the next section.

Figure 1. Propensity Scores



Matching groups.

The next step in the propensity score process was to identify matches between the treatment and control groups. Propensity scores will range from 0 to 1, and the closer a score is to one the more likely that the school would be in the treatment (1:1), or similar to schools in the treatment. Prior to matching, the data analysis program Stata was used to produce histograms of the 1:1 and non-1:1 schools, and the histogram confirmed the group differences. The scores from the 1:1 and non-1:1 schools were different. However, the histogram also revealed there was an area of common support between the two groups. The schools that fall in the area of common support are the ones that have a similar school in the opposite group. Those schools are the ones that were targeted for inclusion in the study. Although there are multiple methods of matching the groups, nearest neighbor matching was employed in this model. Nearest neighbor matching, as the name implies, entailed matching schools from the treatment group with their nearest neighbor in the control group. Each school's nearest neighbor was the school with the closest propensity score. It is actually possible, and preferable, to match a treatment school with more than one control school (Guo & Fraser, 2010; Smith, 1997). Smith (1997) noted that doing so can increase efficiency of the procedure and reduce bias. In this study, treatment schools were allowed to be matched with up to six control schools. When creating nearest neighbor matches, it was desirable to set up calipers so two dissimilar groups were not matched simply because they are closer to one another than anything else. Stata was used to pair the schools with the Psmatch command and also has a function to create calipers on the match. The calipers help ensure that the matched schools have similar propensities. Although there is not a rule for how wide or narrow the calipers should be set, typically they are set at 25% of the standard deviation of the propensity score. For this study, the caliper was set at 50% because of the small number of schools in the study. Schools that did not have matches within that caliper were removed from the data. After completing the matching process, 112 schools were identified to be included in this study. Thirty-seven of those schools were 1:1 schools, and 75 were non-1:1 schools. Table 3 identifies the number of matches for each of the treated schools.

Table 3
Number of Matches for Each Treatment

Number of matches	Number of Treated Schools
0	1
1	0
2	0
3	5
4	1
5	1
6	29

Note: Matches were made using a caliper with a standard deviation of .5 of the median propensity score.

Post-matching analysis.

Once propensity scores had been generated and treatment and control groups had been matched, variables were compared for the two groups. The Stata command “pstest” calculated several measures of the variables before and after matching occurred. Tables 4 and 5 contain he results of that test. Those results revealed that propensity score matching effectively identified control and treatment schools that looked like one another.

The means before (unmatched) and after (matched) matching occurred reveal the variance in the means of nearly every variable was greatly reduced. Also, Pstest identifies the percent bias reduction from the unmatched to the matched sample. The bias statistic explains the differences in means between the control and treatment schools before and after matching. Table 4 reveals that the percent of bias was reduced in all but one of the variables. That reduction in bias for the entire group of variables was from 36.87% prior to matching to 6.39% after matching had occurred. The reduction in bias and reduction in the differences between means are evidence the matching was successful. Table 4 contains the results from the pre- and post- matching t-tests between the 1:1 and non-1:1 schools. Those t-tests identified the mean scores for 1:1 and non-1:1 schools, and whether or not those tests were statistically significant. All 269 schools identified for possible inclusion in the study were included in these t-tests. Table 4 reveals the results from those tests, and 11 of the 22 variables were statistically significant ($p < .05$) prior to matching. The differences in groups can also be seen when analyzing the unmatched and matched means which can be found in Table 5. That table highlights how the matching helped create treatment and control schools that looked like one another.

Using propensity scores to identify treatment and control schools with similar characteristics strengthened this study. Although it isn't a random sample, the control and treatment groups looked very similar because of propensity score matching.

Table 4

Pre and Post Matching t-tests for 1:1 and Non-1:1 Schools

	Unmatched		Matched	
Variable	t	% Bias	t	% Bias
School Enrollment	-3.68***	-84.5	0.49	3.2
% Prof. 11th Math	-0.99	-18.4	-0.75	-17.3
% Prof. 11th Reading	-1.01	-19.3	-0.33	-7.2
% Female	1.05	16.4	0.26	6.8
% Nonwhite	-2.27*	-50.4	-0.31	-3.4
% Free and Reduced	0.84	15.9	-0.04	-0.9
Student to Teacher Ratio	2.02*	18.7	0.28	0.4
% ELL	-1.39	-30.3	-0.17	-2.4
% IEP	-0.22	-3.8	0.31	7.9
Local Revenue	2.79**	46.2	-0.14	-3.6
% Discipline Occurrences	-1.56	-33.1	-0.41	-6.1
Students per Computer	-2.36*	-43.6	-0.08	-1.8
Graduation Rate	1.32	27.0	-0.28	-5.0
Teacher Avg. Age	1.93	33.7	0.25	6.1
Teacher District Experience	1.55	25.4	0.57	13.6
Principal District Experience	-1.89	-29.0	0.48	11.5
Age of Principal	-3.46**	-58.0	0.48	13.4
Superintendent District Experience	-2.2*	-43.7	0.19	3.2
Rural	3.56***	71.9	-0.13	-2.2
% over 25 with College Degree	-2.12*	-45.3	0.12	1.9
% over 16 in Labor Force	-2.55*	-46.0	-0.79	-16.9
Medium Family Income	-2.61*	-50.6	-0.30	-5.8

*p < .05. **p < .01. **p < .001.

Table 5

Pre and Post Matching Means for 1:1 and Non-1:1 Schools

	Unmatched Means		Matched Means	
Variable	Treated	Control	Treated	Control
School Enrollment	246.30***	525.89	244.08	233.41
% Prof. 11th Math	78.57	80.09	78.50	79.93
% Prof. 11th Reading	77.01	78.61	76.83	77.43
% Female	49.13	48.59	49.17	48.95
% Nonwhite	3.86*	7.63	3.90	4.15
% Free and Reduced	26.86	25.21	27.10	27.19
Student to Teacher Ratio	20.21*	13.38	11.71	11.58
% ELL	1.10	2.51	1.13	1.25
% IEP	13.72	13.84	13.74	13.47
Local Revenue	53.17**	49.63	53.35	53.63
% Discipline Occurrences	8.11	11.85	8.05	8.74
Students per Computer	2.76*	3.27	2.71	2.73
Graduation Rate	94.45	92.89	94.52	94.80
Teacher Avg. Age	42.71	41.88	42.65	42.50
Teacher District Experience	12.07	11.43	12.04	11.70
Principal District Experience	7.44	9.49	7.33	6.52
Age of Principal	43.37**	46.95	43.35	42.52
Superintendent District Experience	4.48*	7.39	4.47	4.26
Rural	0.89***	0.59	0.89	0.90
% over 25 with College Degree	18.81*	22.79	18.86	18.70
% over 16 in Labor Force	65.85*	68.09	65.69	66.51
Medium Family Income	4.41*	4.77	4.39	4.43

*p < .05. **p < .01. **p < .001

Multilevel modeling

The second part of this research design used a random intercept multilevel model, which was an effective way to deal with the data that had been collected. Multilevel modeling allowed data to be looked at on multiple levels. The terms “nested” or “nesting” are used to describe the data at the different levels. In this model, teachers are nested within schools. Rather than looking at all of the data as one pooled data set, data can be analyzed at both the school (group) and teacher (individual) level. Even more importantly for this model is that the multilevel model takes the nesting relationships and variability in each level into account to help produce a more effective model. If these items are ignored, it is very possible to draw the wrong conclusions from the model (Snijders & Bosker, 1999). Bryk and Raudenbush (1992) listed three main research purposes for multilevel modeling: the improvement of estimation of individual effects, the modeling of cross-level effects, and the partition of variance-covariance components. The first and last of those purposes are important for this study. Improved estimation of individual effects will result in the ability to make stronger inferences even with smaller teacher sample sizes. This occurs because schools with low response rates can borrow strength from the entire data set (Bryk & Raudenbush, 1992). Partitioning variance-covariance components allowed the model to more accurately identify where most of the variance occurs in the model. Another way to think of the benefits of a multilevel model is to consider the example of a study that attempts to analyze the impact of teacher’s experience teaching on student achievement. A typical regression model would simply include one variable for each teacher’s experience, and produce a coefficient for experience. That coefficient would then be reported as the impact of experience on achievement. Multilevel modeling will go one step further and take into account the average teaching experience of the school. Multilevel modeling will not only take into account the experience of an individual teacher, but also the overall average teacher experience of the school. A traditional regression model would not take into account the relationship between the teachers and their school, and instead assume that every teacher is independent and unrelated to one another. It assumes that group, or school where a teacher teaches, has no impact on any of the outcome variables.

Multilevel models can be either fixed effects models or random coefficient models. This study will employ a random coefficients model. Snijders and Bosker (1999) noted numerous reasons to use a random coefficients model, but two reasons in particular are relevant to this study. The first is that if groups are regarded as a sample from a population and the researcher wishes to draw conclusions pertaining to the population, the random coefficient model is appropriate. The second is for cases where the group size is relatively small. In those examples, there are important advantages of using the random coefficient model (Snijders & Bosker, 1999). This study falls under both of those guidelines. The schools and teachers in the model are a sample from the larger population of schools and teachers, and the size of the groups is also fairly small (<100).

The literature on multilevel models generally focuses on four different models. The empty, level-one, level-two, and full model are all parts of the multilevel design. Each level of the model builds off of the previous model. This building process begins with the empty model and progresses to the full model, which is the model of interest in this study. Each of those steps are described in detail below, however the full and empty models are the only models described in the results section of this study. Those models are used because they best answer the research questions from this study.

Empty model.

The empty model gets its name because it does not take any group or individual variables into account. The model is important because it can be used to determine where most of the variance occurs in the model.

$$Y_{ij} = \gamma_{00} + \mu_{oj} + r_j \qquad \text{Equation 1.1}$$

Y_{ij} = Outcome (of selected dependent variable Y) for teacher i in school j

γ_{00} = Mean of Y

μ_{oj} = error term at the group (school) level

r_j = error term at the individual (teacher) level

This model will produce a coefficient for the intercept and a variance component for both level one teacher and level two school variances. Using the variances from this model, the intraclass correlation can be generated by using the following formula.

$$\hat{\rho} = \frac{\Gamma_o^2}{\hat{\Gamma}_o^2 + \sigma^2} \qquad \text{Equation 1.2}$$

$\hat{\rho}$ = Intraclass correlation between schools

Γ_o^2 = Level 2 (school) variance

σ^2 = Level 1 (teacher) variance

The result of this formula will be the intraclass correlation coefficient of $\hat{\rho}$ where $\hat{\rho}$ represents the part of the variability that is due to schools. These level two coefficients are almost always much lower than the level one coefficients. Values of .05 to .20 are common for these level two correlation coefficients (Snijders & Bosker, 1999). As the full model was designed for this study, the empty model provided details as to where much of the variance existed. This model indicates if most of the variance is due to teacher or school-level variables.

Level 1 model.

The level 1 model is the first analysis into the relationship of variable Y for teacher i at school j. The model only contains individual level variables and can be written:

$$Y_{ij} = \beta_{oj} + \beta_{1j}X_{ij} + R_{ij} \qquad \text{Equation 1.3}$$

Y_{ij} = Outcome variable Y for teacher i in school j

β_{oj} = Intercept of Y (For the school that Y_{ij} belongs to)

β_{1j} = Regression coefficient of teacher i at school j

X_{ij} = Individual variable X for teacher i at school j

R_{ij} = Error term for teacher i in school j

This is a simplified model and multiple teacher-level variables can be added. Although this model is not discussed in the results section, it is helpful when thinking about the design of a multilevel model.

Level 2 model.

The level one model lacks some important components. In order to include a school-level error term as well as a population mean, a separate equation can be specified for the intercept.

$$\beta_{oj} = \gamma_{00} + \mu_{oj} \qquad \text{Equation 1.4}$$

γ_{00} = Average outcome for the population on variable Y

μ_{oj} = Error term for the school

By using this part of the formula with the equation from above, the effect of random intercepts for groups is accounted for. This is essential for this study, and this is why a multilevel model was used.

Full model.

Level 1 (Equation 1.3) and level 2 (Equations 1.4) models can be combined to create a full model (Equation 1.5). Equation 1.3 included one individual teacher variable (X) and no school-level variables. In order to create a more complete model, both individual and group variables can be added to the model to create a full model.

$$Y_{ij} = \gamma_{00} + \gamma_{01}(Onetoone_J) + \gamma_{02}(Z_{1J}) + \gamma_{10}(X_{1ij}) + \gamma_{11}(X_{2ij}) + \mu_{oj} + R_{ij} \qquad \text{Equation 1.5}$$

Y_{ij} = Outcome variable Y for teacher i in school j

γ_{00} = Average outcome for the population on variable Y

γ_{01} = Regression coefficient for school j

$Onetoone_j$ = Dichotomous variable to indicate a school's 1:1 status

γ_{02} = Regression coefficient for school j

Z_{1J} = Group variable for school j

γ_{10} = Regression coefficient for individual i in school j

X_{1ij} = Teacher variable for teacher i in school j

γ_{11} = Regression coefficient for individual i in school j

X_{2ij} = Teacher variable for teacher i in school j

μ_{oj} = School-level error term

R_{ij} = Teacher error term

This full model takes into account both individual (teacher) and group (school) level variables. In Chapter 4, the empty model and four additional full models are reported for each of the three different dependent variables. For each of these models, it is assumed that the error terms (μ_{oj}, and R_{ij}) are mutually independent and have zero means given the values of X_{ij}.

Population and Sample

This study was a bit unique in that it actually had two populations because of the nature of the multilevel design. Multilevel models which have data nested within data have separate populations for both the micro (teacher) and the macro (school) level.

The population for the teachers in this study was restricted to high school teachers who are employed in the schools that were part of the sample in the study. The target population for the school-level in this study was all high schools in the state of Iowa that met multiple criteria. Those processes for narrowing the population of schools are described below.

First, schools that were in their first year of 1:1 implementation were not eligible for the study sample. Transitioning to a 1:1 program is a process, and those schools in year one were just at the infancy stages of implementation. As first-year 1:1 schools, they most likely don't fully represent a 1:1 school, but they also certainly aren't representative of a non-1:1 program either. Schools were identified conducting Internet searches on all schools eligible for the study. Table 6 displays statewide information about Iowa schools in 2007-08 as well as information about 1:1 status.

Table 6
Statewide High Schools

	Total Schools	First Year 1:1 School	Veteran 1:1 School
Number of Schools	355	42	43

Note. Veteran 1:1 schools are those schools that were 1:1 schools prior to the 2011-2012 school year.

The second process for removing schools from the population of the study was through the use of propensity scores, which were described in the research design section. Those schools that did not have a match within the specified caliper were also not part of the sample. It is important to note that because propensity scores were used, it was possible and preferable to match one treatment school with multiple control schools. Schools were also removed from the study if their status changed between 2007 and 2012. For example, schools that began whole grade sharing during that time were removed. Those schools had to be removed because of the ways that data were reported for those schools. Schools that were closed, non-traditional high schools, and those missing data were also removed from the sample. Table 7 lists the breakdown of the reasons that schools were removed from the sample.

Table 7
High Schools Excluded from Study

Reason for Excluding	Number
First year 1:1 school	42
Sharing or consolidated after 2007	29
Missing data	9
Non-traditional high school	4
Closed	2
Total schools excluded	86

Note: Some schools may fall into multiple categories, but they were only listed in one.

All teachers who teach at high schools in the school sample were included in the teaching population for the purpose of the study. The survey given to teachers included a filter question that asked what grade level they taught. If they indicated that they did not teach at a high school grade level, they were removed from the study. One of the benefits of a multilevel model is if there were teacher responses from a school, the school could be included in the sample.

Data Collection Methods

Data collected for this study used primarily three separate sources. General information about the schools and their staffs were collected using data from the Iowa Department of Education (2012) and the National Center for Education Statistics (2012). The third data source was an online survey used to collect teacher data. Propensity scores had to be generated prior to teacher surveys, so they were created using only the first two sources listed. The multilevel model used data from both the teacher surveys and the state and national data sources.

The Iowa Department of Education and the Common Core Data included staffing, student, community and building data from all K-12 public schools in Iowa. Most of the information is available to the public on both of their websites. Some additional data was gathered from the Iowa Department of Education through personal emails (M. Dorenkamp, personal communication, November 12, 2011; B. Lundy, personal communication, January 17, 2012). Appendix A lists all of the variables for the study and the data source for each variable. Data about the schools was either school level data, district level data, or community data. The first school-level category included data specific to the school buildings that were part of the study. For example, enrollment was considered a school-level data source because it reflected the enrollment of just the school building in the study and not the district. District level data included information about the entire school district and not just the specific building in the study. An example of district level data would be the percent of students who have an individualized education plan (IEP) because that data was reported for the entire school district and not just the school building in the study. The final category of variables was community data. Although this was essentially district data, the term community was used because the data described the community rather than just the school. An example of community data would be the median family income variable. Description of all variables can be found in Appendix A.

Teacher data for this study was generated through a survey that was modified from one created by Hutchison and Reinking (2011). Their development and validation processes included the following components: Constructs were initially established based on their research questions and the literature on the topic. A focus group was then consulted to gather feedback from the intended audience for the survey. Survey items were then revised and a pilot survey was given to 100 teachers. The researchers then conducted an item analysis on the items they hypothesized would represent the constructs. Cronbach's alpha was calculated to examine the internal consistency, and those values ranged from .82 to .96 for the constructs they had identified. Following the pilot survey, items were revised to create the final version of the survey. Their final survey results also indicated high reliability and validity. The two constructs from their survey that were of interest to this study were the "extent of integration" and "competency" constructs. Each of those constructs is described in more detail in the study variables section of this chapter. The reported item loadings on the extent of integration component was between .38 and .83 and had a Cronbach's alpha of .92. For the competency component, item loadings ranged from .76 to .90 and the Cronbach's alpha was .80. All of these levels are within acceptable ranges (George & Mallery, 2003).

Although Hutchison and Reinking's survey was designed to analyze technology in relation to literacy instruction, most survey items were easily adaptable to the general population of a school. Most of the questions required very minor changes to make them applicable to this study while others required no changes at all. The most frequent change in the survey questions was the removal of the word literacy so the question would become applicable to all teachers. The entire survey can be found in Appendix E.

Survey administration

The survey for this study was administered through the use of online surveys emailed to participants. The email explained the study, and contained a link to the survey. The message sent to participants clarified that by clicking on the link and taking the survey, they were willing to participate in the study. An email delivered Internet survey method was chosen in order to distribute the survey to a large number of participants at very little expense.

Email addresses for all of the teachers in the sample were collected through multiple methods. A first email was sent out to school administrators requesting the email addresses of all of their high school teachers. The response from school administrators was very low, so other methods were used to collect teacher emails. Area Education Agencies (AEAs) were also contacted to request email addresses and three of the nine AEAs agreed to provide teacher email addresses. The final strategy to collect teacher email addresses was to visit school websites to get the email addresses. Most of the email addresses from the survey were gathered using the final strategy, which was a time intensive technique.

Once the final list of email addresses was prepared, an email was sent out to teachers. Various methods were used to increase response rates from participants including reminder emails, a deadline statement, selectivity, and encouragement from building administrators. Prior to sending the email to participants, an email was sent to all building administrators requesting they encourage their teachers to take the survey. The email also allowed administrators to get a more detailed report for their school if they requested one. It is uncertain how many administrators followed-up by encouraging their teachers to participate in the study. Participants themselves were not enticed to participate by offering any type of incentive. A recent study by Kypri, Gallagher, and Cashell-Smith (2004) did not reveal any increase in response rates in their online survey due to incentives, and they indicated careful planning and implementation were more important. A deadline for survey completion and a selectivity statement were both included in reminder emails to participants. Porter and Whitcomb (2003) analyzed potential ways to increase response rates and found that adding a deadline and a selectivity statement significantly increased response rate. Another technique used to increase response rate was to send out reminder emails to participants. Three rounds of emails were sent to the entire targeted sample. Individual schools with low response rates were also targeted beyond those three mass mailings. The Qualtrics survey tool used in this study allowed the reminder email to only go to those individuals who did not previously take the survey or requested to opt out of the survey. Participants also had a progress indicator and a limited number of questions on each page to help reduce breakoff rates on their survey. Surveys that have no progress indicator and those with long pages of questions with no breaks seem to breakoff at higher rates (Peytchev, 2009).

By using multiple strategies to increase response rates, survey participation was most likely increased. Although some of the literature is conflicting about the benefits of the various techniques, there seems to be no harm in employing multiple methods. The following section describes the response rate for this study.

Response rate

Two separate responses rates were recorded for this study. The first response rate represented the response rate from the school-level data and the second response rate was from teacher-level data. Of the 112 schools targeted for this study, there were responses from 110 schools. This was a response rate of 98% and the two schools that did not respond were part of the control group. Calculating the response rate for the teacher data was less precise. The targeted sample for this study was all teachers in the study population. That number was calculated according to the number of emails sent to each school. There were 922 surveys entirely completed and 2,508 emails sent to teachers for a response rate of 37%. However, it was not possible to get an extremely precise number for the response rate for two major reasons. The number of teachers in the population is imprecise because it was created by finding the sum of the number of teacher email addresses. Unfortunately, those emails did not entirely reflect the population of teachers. The email addresses gathered from school websites could be incomplete or incorrect because schools do not keep their websites accurate. With that factor in mind, the response rate would actually be higher for the study than reported. The second factor to consider is some principals also forwarded anonymous survey links to their teachers. For that reason, there may have been some teachers who took the survey that weren't in the total population count because they were not listed on their school websites. Their impact on the response rate would actually make it lower for the study. There is no indication that either of these factors had a large impact on the response rate.

The breakoff rate for teachers in this study is also a little imprecise because there were some teachers who took the survey that were not part of the study population. Unfortunately, because they did not answer the question in regard to where they teach it wasn't possible to determine if they should be included in the breakoff rate for the study. In order to report the highest breakoff rate, all 133 individuals who did not answer the question in reference to where they taught were included in the calculations to determine breakoff rates. The breakoff rate calculated using those numbers was 25%.

Study Variables

Because there are two major components in the study design, the variables were somewhat unique for each model. The variables used to generate propensity scores were also used in the multilevel model. However, the teacher-level variables in the multilevel model were not used to generate propensity scores.

In order to generate propensity scores, a logistic regression model was used to determine the probability that a school was a 1:1 school. The status of whether a school is actually a 1:1 school was the dichotomous dependent variable in the propensity scores model. The independent variables in this model could not be assumed in advance because multiple techniques described previously were used to select the correct variables. Put more succinctly, the model included variables that may explain why a school made the decision to implement a 1:1 program. With a lack of literature on that topic, there can only be speculation about those factors and a large number of independent variables were included. The final 22 variables used to generate propensity scores can be found in Appendix A.

Three dependent variables were created in order to answer the research questions in this study. Those variables were all created from the Hutchison and Reinking (2011) survey. The first dependent variable attempted to help answer the research question about the time students were using technology. The variable was created from “Q2” on the survey, which consisted of a 7-point Likert scale. Results were interpreted using the raw scores from that question. The second dependent variable targeted the research question about integration. It was created from 14 unique items and labeled “Q3” on the survey. Those items were added together to create a raw score, which was then transformed into a standard deviation score in order to help make the results more interpretable. The working definition for integration in this study is the extent of use of various technologies in the classroom. The 14 items from the survey would be the various technologies analyzed for the purpose of this study. The final dependent variable was the competency variable, and it was created from items five and six on the survey. Those items were added together to create a raw score, which was also transformed into a standard deviation score. The entire survey can be found in Appendix E. The multilevel models described in the results section can be found in Appendix B.

Independent teacher-level variables were also used in the multilevel model in this study. Those variables were collected using the survey and they are included in some of the multilevel models described in Chapter 4. Those teacher variables were age, race, content area taught, years teaching, and extent of technology use in college. Chapter 4 includes a further analysis of those variables.

Data Analysis

The data analysis and statistical software package Stata was used in the statistical analysis in this study. The first major part of the study involved using Stata to generate propensity scores that enabled matching between 1:1 and non-1:1 schools. The second part of the study embraced a multilevel model in order to address the nature of the nested data. Two unique Stata commands were used to generate results for the multilevel model.

Stata allowed propensity matching to occur somewhat easily once all data had been collected. By using the psmatch command and setting parameters for the calipers (.50) and the number of matches (6), Stata identified 112 schools to include in the study. In order to verify the results of the psmatch command, a logistic regression model was also executed with 1:1 status as the dependent variable. That model produced probability scores for each school in the sample. Those scores did, as they should have, align with the scores generated by psmatch.

Once the schools for the study had been identified, numerous multilevel models were generated for each of the research questions. Stata has two commands, xtmixed and xtreg, that were used to analyze multilevel models, and both commands were used to verify results. The first test run for each model identified the intraclass correlation coefficient (ICC). The ICC indicates what percent of variance exists between schools. Snijders and Bosker (1999) reported values of .05 to .20 are common in educational research.

The next step used to create the multilevel models was to include the dependent variable of interest and selected independent variables. The three dependent variables were time, integration, and competency. Four multilevel models were created for each of those dependent variables. The first model included a dependent variable and only included 1:1 status as the independent variable. The next model added teacher-level variables. The third model included all of the variables from the aforementioned models as well as a select group of school-level variables. The final model included all of the variables listed above as well all variables used in the propensity score matching. Chapter 4 walks through each of those different models for each of the research questions in this study.

Limitations

Like any research, there are limitations to this study. One of the initial steps in this study was to develop a model to create propensity scores for schools. Shadish (2010) noted that propensity scores certainly are most effective when appropriate variables are used to develop the actual propensity scores. Ideally, those propensity scores should include variables based on the literature surrounding the topic. Unfortunately, there is no literature pertaining to the factors that led to schools becoming 1:1 schools. A second limitation with the propensity scores is that the data used to create propensity scores were limited to what is available from the Iowa Department of Education and the Common Core data. Ideally, other data from things such as principal, teacher, and board surveys would be used to generate propensity scores.

Building models that contain appropriate variables was a challenge with this research as it is with any observational design. Including the wrong variables, too many variables, or too few variables were all potential weaknesses in the research design. There are also different types of potential errors with the survey. One major concern is undercoverage, which may become a factor for two reasons. The first reason is simply teachers who are not very technologically savvy may be apprehensive about completing the survey. Using an online survey increases both the technical requirements of users and the steps needed to complete the process (Best & Krueger, 2004). This limitation was hopefully minimized simply because of the widespread use of computers by most teachers today. Another reason for concern with undercoverage is simply that a certain type of teacher is more likely to fill out the survey.

Another limitation to this study was the process used to identify which schools had 1:1 programs, and how long they have been a 1:1 school. The state of Iowa does not collect that data, so data were collected using multiple sources. Internet searches, phone calls, and emails were all used to correctly identify those schools. Various organizations were also contacted and multiple lists were cross-referenced.

This entire research design has been developed in an attempt to best answer the research questions presented. Although there are limitations, the design aimed to provide meaningful results to help add insight into the research questions.

Ethical Issues

Like almost any study involving participants, confidentiality is essential. This study obtained IRB approval prior to conducting surveys with participants. Appendix C contains the IRB approval letter. Participants had the opportunity to not take the survey or discontinue taking the survey at any time. Participant names were not collected, but Qualtrics was able to identify which individuals had already taken the survey so duplicate emails were not sent out to individuals. Those records were kept confidential and will be deleted upon completion of this study.

Summary

The methodologies described in this chapter were designed to reduce some common concerns that often occur in research. Although a random sample wasn't used, the study strived to create samples that are very similar to one another through the use of propensity scores. Once the sample for the study was identified, the multilevel model added value to this study. It brought additional statistical power to the study and explained the variance at both the teacher and the school-level. Employing these two statistical techniques helped better answer the research questions in this study.

CHAPTER 4: RESULTS

The results in this chapter explore the relationship between a school's 1:1 status and three unique dependent variables. Each dependent variable is representative of one of the three research questions in this study and stems from one of the two theoretical frameworks described in Chapter 1. The schools included in this study were selected using propensity score matching. This chapter begins with a short description of the study design, and is followed by a discussion of the study variables. The final section describes the results from the multilevel models for each of the three research questions.

Study Design

The results of propensity score matching were discussed extensively in Chapter 3, but this section provides a brief overview of the process. Propensity score matching was used as a strategy to create treatment and control groups that looked very similar to one another on multiple measures. This study initially analyzed 269 high schools to identify the treatment and control schools for the study. Stata was used to create propensity scores for each school in the study based on 22 variables. Once those scores were created, 112 schools were identified for the study. Surveys were sent to teachers at each of the 112 schools. Teacher responses were turned into variables and combined with data from their schools. Each of the 922 individuals in the study then had both individual and teacher-level data. The final step in this study involved using multilevel models to analyze the impact of a school's 1:1 status on each of the three research questions on this study. Those models and results from each model are described extensively in the results section of this chapter.

Study Variables

The following section contains descriptive statistics about the variables that were used in the multilevel model. Those variables are divided into one of three categories. The first group of variables is made up of teacher-level independent variables that were reported on the teacher survey. The second category is made up of the school-level variables, and the final category describes the dependent variables for the study.

Teacher-level independent variables

Although multiple teacher-level variables were collected on the survey, the multilevel models only contain those independent variables for teacher age and content area. Variables that were excluded from the study included teacher race, years teaching, and extent using technology in college. The race variable was excluded because of the small number (< 15) of responses that were not in the White category. The variables for years teaching and extent using technology in college were excluded because of their high correlation with the age variable. Their correlations with the age variable were .81 and -.67 respectively. As discussed previously, there is not an agreed upon cutoff of correlation levels for excluding variables. The two variables that were removed here were excluded because they did appear to measure a value that was closely related to the age variable.

The age variable was divided into four categories with 10-year age spans and one category for participants over 61. Table 8 displays the number of individuals in each of the categories. It is important to note that in the multilevel model, the *20- to 30-year-old* group is left out. Because age variables were included as dummy variables, the *20- to 30-year-old* group was left out of the model to act as the comparison category.

Table 8

Teacher Age

Age	1:1	Non-1:1	Total
20-30	59	123	182
31-40	64	136	200
41-50	98	158	256
51-60	78	153	231
61 plus	36	17	53

The second Teacher-level variable included in the multilevel models was the content area variable. Content area was also classified as a dummy variable with ten unique categories. The categories are reported in Table 9. The other category was a self-selected category on the survey. Participants who selected “Other” were able to type their content area into the survey. The responses they typed were analyzed, but none of them were large enough to create another category to include in the multilevel model. The largest category created by participants was “Guidance Counselor”, but there were only 21 responses in that category. Those “Other” responses that aligned with one of the survey content area categories were reclassified. On the multilevel models, the Language Arts category was used as the reference category for all of the other content areas. It was selected because it was the largest core content area, and also because of the literature related to 1:1 programs and writing. Numerous studies have identified writing as one of the areas where 1:1 schools have seen the most improvement (see, e.g., Bebell & Kay, 2010; Gulek & Demirtas, 2005; Lowther, Ross, and Morrison, 2003).

Table 9

Content Area Taught

Content Area	1:1	Non-1:1	Total
Fine Arts	43	64	107
Foreign Language	22	39	61
Language Arts	37	84	121
Math	34	60	94
PE/Health	12	30	42
Science	24	69	93
Social Studies	29	43	72
Special Ed.	29	61	90
Vocational Ed.	60	119	179
Other	26	37	63

School-level independent variables

The variables described in this section include those school-level variables that were included in the multilevel model. It is important to note that these values are different than those reported in the section on propensity scores. The propensity score variables were created using the mean values for each of the 269 schools eligible for participation in the study. The mean values reported here were generated by including the school values for each individual who took the survey. A school that had a high number of individual responses would therefore have a greater impact on the overall mean of the study. T-tests were run on the treatment and control groups to determine which variables had statistically significant values ($p < .05$), and those variables are displayed in Table 10.

Table 10

Group Means on Survey Responses

Variable	Group Mean 1:1	Non-1:1	Total
School Enrollment	255.44	295.77	281.95
Student to Teacher Ratio	11.84	12.48	12.26
Local Revenue	53.77	50.96	51.92
Age of principal	42.38	45.97	44.74
Supt. Dist. Experience	3.70	5.78	5.07
Rural	0.88	0.79	0.81
% >16 in Labor Force	65.58	66.59	66.25
% IEP	13.64	14.20	14.01
Graduation Rate	94.78	93.53	93.96
Dist. Experience Principal	6.82	8.40	7.86

Note. These variables were statistically significant ($p < .05$) between 1:1 and non-1:1 group means.

Dependent variables

The first dependent variable in the study was created from a survey question that asked teachers how often their students used technology during the past year. The results were reported on a 7-point Likert scale with "*Not at all*" and "*Daily*" as endpoints for the scale. Teacher responses can be seen in Table 11.

Table 11

Student Time Using Technology

	1:1	Non-1:1	Total
Not at all	2	19	21
A few times during the year	16	67	83
Once a month	8	40	48
2-3 times a month	14	89	103
Once a week	28	101	129
A few times each week	95	159	254
Daily	153	131	284

Note. The numbers reflect the number of teachers who selected each of these categories.

The second dependent variable in the study was the "Integration" variable which was created with 14 items on the survey. Those items dealt with the technologies that teachers used in their class and responses were given on a 4-point scale. A raw score was generated for integration by adding each of the items together. The maximum possible score was 56 and the minimum score was 14. The mean score for 1:1 teachers was 30.38 and 25.73 for non-1:1 teachers. The overall mean for integration was 27.33. In order to generate a more easily interpretable variable, the "Integration" variable was transformed into a standard deviation variable using Stata. With the new standard deviation variable created, the coefficient for integration could be interpreted as the increase or decrease in standard deviations.

The final dependent variable was the "Competency" variable which was generated from two items on the survey. Those items asked for teachers' skill level using digital technology for instruction and in general. The response scale was a 4-point scale that ranged from "*Not at all*" to "*Large extent*". The minimum raw score was 2 and the maximum score was 8. The mean score for 1:1 teachers was 6.32 and 5.96 for non-1:1 teachers. The overall mean for competency was 6.08, and a standard deviation score was generated for easier interpretation like the integration dependent variable.

Results

Multilevel models were used to answer each of the three research questions in this study. The following section presents the analysis for each research question using a common format. The first model in each section only included the dependent variable and a school's 1:1 status. The second model built on those two variables and added teacher-level variables for content and age. The third model included all of the aforementioned variables as well as school-level variables that were identified as significant on Table 10. The final model added all of the school-level variables that were used to create the propensity scores as well as the variables from the first three models.

It is important to note that school-level variables were only included to account for potential differences between the schools in the study. Those data contained the 2007-2008 data that were used to generate propensity scores. It isn't possible to interpret those data in a meaningful way, and they have been left out of the discussion throughout this paper.

Prior to creating the models described above, an empty model was created to identify the intraclass correlation (ICC) for each dependent variable. The ICC of each model indicated the part of the variability in the dependent variable that is due to schools. Values of 0.05 to 0.20 are common in education and two of the three ICC scores in the study fell within those values (Snijders and Bosker, 1999). The ICC score for time was 0.11 which indicated that 11% of the variance in time scores was due to the effect of the group. The ICC score for integration was 0.14, and the competency variable had the lowest with an ICC score of 0.04. These values would indicate that the competency scores of an individual were much less dependent on the school where they teach, than integration or time scores were. The alternative description of that would be that an individual's competency score was much more highly related to the individual than the group. These results are in line with ICC scores that would be expected from the research literature.

Research Question 1

Do teachers at 1:1 schools report that their students use technology more frequently than teachers at non-1:1 schools?

The first model created to answer this question simply included the dependent variable of time and the independent variable of a school's 1:1 status. This is the most basic of the four models. The results of this model produced a coefficient of .61 for 1:1 status and a p-value that was statistically significant at the .001 level. The interpretation of this would be that teachers at 1:1 schools had time scores that were .61 of a standard deviation higher than the non-1:1 teachers. Results from all of the models for this research question can be found in Table 13.

The second model included teacher variables for age and content which were both dummy variables. The reference or comparison category for age was the *20- to 30-year-old* category and *language arts* was the reference category for the content area variable. The coefficient for 1:1 status was again significant at the .001 level and very similar to the value from the first model. None of the age variables were statistically significant, but six of the content areas were statistically significant ($p < .05$). The fine arts coefficient was -0.99 with a p-value of less that .001. The interpretation for that coefficient would be that fine art teachers had time scores that were 0.99 of a standard deviation lower than language arts teachers. It is important to note, that these results are not treating 1:1 fine arts teachers and non-1:1 fine arts teachers as separate categories. The age and content area variables are simply reflective of those groups of teachers as a whole.

The third model added the school-level variables that were reported in Table 10. Those school level variables had statistically significant differences between the 1:1 schools and non-1:1 schools in the study. The coefficient for 1:1 status is once again significant, and the coefficient is higher than the first two models (0.67). None of the age variables were significant in this model either, and the same content area variables were significant in this model.

The final model (Model 4) added all of the school-level variables that were used to generate propensity scores. The 1:1 status produced a coefficient that was very similar to the third model and also was statistically significant ($p < .001$). The statistical significance for all of the variables from the previous models did not change in this model.

Table 12

Reported Coefficients with Time Dependent Variable

	Coefficients			
	Model 1	Model 2	Model 3	Model 4
1:1 Status	1.041***	1.063***	1.140***	1.131***
Age 31-40		0.101	0.107	0.103
Age 41-50		0.129	0.127	0.116
Age 51-60		0.057	0.069	0.061
Age Over 61		-0.350	-0.333	-0.350
Fine Arts		-1.684***	-1.677***	-1.689***
Foreign Language		-0.552*	-0.573*	-0.571*
Math		-0.848***	-0.877***	-0.875***
PE/Health		-1.216***	-1.244***	-1.257***
Science		-0.450*	-0.458*	-0.453*
Soc. Studies		0.093	0.100	0.103
Sp. Ed.		0.523*	0.505*	0.522*
Voc. Ed.		0.306	0.296	0.295
Other		0.297	0.269	0.307
School Enrollment			0.001	0.000
Student to Teacher Ratio			-0.017	-0.012
Local Revenue			0.005	0.002
Avg. Principal Age			0.006	0.007
Supt. Dist. Experience			0.019	0.014
Rural			0.241	0.118
% over 16 in Labor Force			0.008	-0.005
% IEP			-0.001	0.007
Graduation Rate			-0.019	-0.028*
Dist. Experience Principal			-0.001	-0.002
% Nonwhite				-0.012
Students per Computer				-0.030
% over 25 with College Degree				-0.008
Median Family Income				0.130
% Prof. 11th Math				-0.001
% Prof. 11th Reading				0.003
% Female				-0.004
% Free and Reduced				-0.006
% ELL				-0.018
% Discipline Occurrences				-0.017*
Teacher Avg. Age				0.037
Teacher Avg. Dist. Experience				-0.042

Note. Variables are described in Appendix A.

* $p < 0.05$. **$p < .01$. ***$p < .001$.

Research Question 2

Do teachers at 1:1 schools report that they integrate technology differently than teachers at non-1:1 schools?

Model 1 for this research question also simply included the dependent variable for integration which was reported as a standard deviation score. The model identified a statistically significant ($p < .001$) coefficient of .59. The interpretation of this is that teachers at 1:1 schools had integration scores that were 0.59 of a standard deviation higher than the non-1:1 teachers. Results from all of the models for this research question can be found in Table 13.

Adding the Teacher-level variables for age and content area created the second model. School's 1:1 status was again significant ($p < .001$) with a coefficient of 0.61. Two of the age variables were statistically significant at the .001 level, while the other two categories were also significant ($p < .05$). The reference category for age was the *20- to 30-year-old* category, which would indicate individuals in that category had significantly higher integration scores than all other categories. The interpretation for individuals in the 31-40 category, which had a coefficient of -0.23, would be as follows. Teachers who were between the ages of 31 and 40 had integration scores that were 0.23 of a standard deviation lower than teachers between 20 and 30. Five of the content areas were statistically significant ($p < .01$). They all had lower scores than the language arts reference category. The interpretation for math, which had a coefficient of -0.29, would be as follows. Math had integration scores that were 0.29 of a standard deviation lower than language arts teachers.

Model 3 added school-level variables from Table 10 and the coefficient for 1:1 status increased to 0.66 which was still statistically significant ($p < .001$). None of the variables for age and content had substantive changes in their significance level.

Model 4 added the remaining school variables used in creating propensity scores. The coefficient for 1:1 status was very similar to the previous model (0.65) as were the age and content area variables.

Table 13

Reported Coefficients with Integration Dependent Variable

	Coefficients			
	Model 1	Model 2	Model 3	Model 4
1:1 Status	0.282***	0.291***	0.315***	0.310***
Age 31-40		-0.095**	-0.096**	-0.088*
Age 41-50		-0.125***	-0.126***	-0.124**
Age 51-60		-0.137***	-0.134***	-0.122**
Age Over 61		-0.114***	-0.109***	-0.103**
Fine Arts		-0.283***	-0.283***	-0.283***
Foreign Language		-0.098**	-0.100**	-0.098**
Math		-0.285***	-0.290***	-0.282***
PE/Health		-0.159***	-0.163***	-0.158***
Science		-0.124***	-0.127***	-0.126***
Soc. Studies		-0.003	0.000	0.005
Sp. Ed.		0.056	0.053	0.060
Voc. Ed.		-0.052	-0.055	-0.051
Other		-0.008	-0.009	-0.011
School Enrollment			0.029	0.010
Student to Teacher Ratio			-0.015	0.011
Local Revenue			-0.008	0.001
Avg. Principal Age			0.063	0.052
Supt. Dist. Experience			0.028	0.032
Rural			0.040	0.054
% over 16 in Labor Force			0.025	0.027
% IEP			-0.084*	-0.063
Graduation Rate			-0.074*	-0.100**
Dist. Experience Principal			-0.030	-0.017
% Nonwhite				-0.058
Students per Computer				-0.011
% over 25 with College Degree				0.039
Median Family Income				-0.071
% Prof. 11th Math				0.021
% Prof. 11th Reading				-0.060
% Female				0.029
% Free and Reduced				-0.011
% ELL				-0.003
% Discipline Occurrences				-0.043
Teacher Avg. Age				0.005
Teacher Avg. Dist. Experience				-0.106

Note. Variables are described in Appendix A.

* $p < 0.05$. **$p < .01$. ***$p < .001$.

Research Question 3

Do teachers at 1:1 schools report higher levels of technology competency than teachers at non-1:1 schools?

The final research question used the competency variable as the dependent variable. The four models used to answer this question followed the same flow as the previous two research questions. Model 1 only included 1:1 status as an independent variable, and the coefficient was 0.29 ($p < .001$). The interpretation of this is that teachers at 1:1 schools had technology competency scores that were 0.29 of a standard deviation higher than the non-1:1 teachers. Results from all of the models for this research question can be found in Table 15.

Model 2 added the teacher-level variables for time and content area. The 1:1 status coefficient was nearly identical to the first model. All of the age variables were statistically significant ($p < .05$), three at the .001 level. All of the coefficients were negative which indicated that all of the age categories reported lower competency scores than teachers in the *20- to 30-year-old* category. Three of the content areas were significant ($p < .05$), and they also had negative coefficients which indicated their competency scores were lower than those of language arts teachers.

Adding the school-level variables from Table 11 increased the coefficient for 1:1 status to 0.35 ($p < .001$) for Model 3. The age and content area variables were not substantively altered.

The final model added all school-level variables and the coefficient for 1:1 status decreased to 0.32 ($p < .001$). The statistical significance of the age and content area variables were not substantively changed from Model 2 or 3.

Table 14

Reported Coefficients with Competency Variable

	Coefficients			
	Model 1	Model 2	Model 3	Model 4
1:1 Status	0.287***	0.292***	0.352***	0.317***
Age 31-40		-0.226*	-0.215*	-0.211*
Age 41-50		-0.498***	-0.499***	-0.507***
Age 51-60		-0.828***	-0.816***	-0.803***
Age Over 61		-0.785***	-0.749***	-0.739***
Fine Arts		-0.126	-0.117	-0.098
Foreign Language		-0.288*	-0.294*	-0.285*
Math		-0.252*	-0.275*	-0.266*
PE/Health		-0.751***	-0.746***	-0.748***
Science		-0.104	-0.109	-0.088
Soc. Studies		-0.136	-0.124	-0.105
Sp. Ed.		-0.207	-0.218	-0.197
Voc. Ed.		-0.076	-0.081	-0.077
Other		0.136	0.135	0.154
School Enrollment			0.000	-0.000
Student to Teacher Ratio			-0.001	-0.004
Local Revenue			-0.000	-0.003
Avg. Principal Age			0.008	0.005
Supt. Dist. Experience			0.000	0.002
Rural			0.151	0.072
% over 16 in Labor Force			0.006	0.004
% IEP			-0.003	-0.001
Grad. Rate			-0.011	-0.013
Dist. Experience Principal			0.003	0.004
% Nonwhite				0.023
Students per Computer				0.043
% over 25 with College Degree				0.007
Median Family Income				0.026
% Prof. 11th Math				-0.004
% Prof. 11th Reading				0.000
% Female				0.011
% Free and Reduced				0.003
% ELL				-0.045**
% Discipline Occurrences				-0.003
Teacher Avg. Age				-0.022
Teacher Avg. Dist. Experience				0.019

Note. Variables are described in Appendix A.

* $p < 0.05$. ** $p < .01$. *** $p < .001$.

Summary

The same research design was used to answer each of the research questions in this study. Schools were initially identified for the study using propensity score matching (PSM). The results from PSM indicated that the control and treatment schools looked much more like one another than comparing the treatment schools to all schools in the state. The second component of this model used a multilevel model to analyze each of the dependent variables that were designed to answer the research questions in the study. Four multilevel models were used for each of the research questions; each model contained a unique set of variables. The results for each of those models were displayed under each question. Although coefficients were reported for numerous variables, the primary focus of this study was the impact of the 1:1 independent variable on each dependent variable. Other variables were included simply to account for other factors that may have been related to the dependent variable. For each of the three dependent variables, the impact of 1:1 status was significant ($p < .001$) in each of the four models. The next chapter addresses the implications of these findings.

CHAPTER 5. DISCUSSION AND IMPLICATIONS FOR PRACTICE

This chapter discusses the results and overall findings of the study. The chapter begins by providing a brief summary of the study design. Findings from the quantitative analysis are then discussed. The chapter concludes with sections on the implications of the study, recommendations for future research, and a conclusion.

Summary of the Study Design

This study was designed to determine the impact that 1:1 programs have had on schools and teachers. The first part of the study used propensity score matching to identify control and treatment schools to include in the study. Once those schools were identified, surveys were sent to teachers at those schools. Survey results then were analyzed using a multilevel model which accounted for data at two levels. The study used data about individual teachers and their schools to most accurately identify the impact of a 1:1 program. Four multilevel models were analyzed for each of the three primary research questions:

1. Do teachers at 1:1 schools report that their students use technology more frequently than teachers at non-1:1 schools?
2. Do teachers at 1:1 schools report that they integrate technology differently than teachers at non-1:1 schools?
3. Do teachers at 1:1 schools report higher levels of technology competency than teachers at non-1:1 schools?

The first model simply contained 1:1 status as a dependent variable. The second model added teacher-level variables, while the third model included both teacher- and select school-level variables. The fourth and final model included teacher-level variables and all of the school-level variables that were used to create the propensity scores for schools.

Discussion

The survey results from this study indicate that 1:1 status has impacted schools in multiple ways. The results also revealed other teacher and school-level variables that have a relationship with the dependent variables in this study. This study differed from many other studies about technology in education. While other studies have attempted to evaluate the worth of educational technologies by focusing on impacts upon student achievement, engagement, or other student measures, this study instead focused on whether or not 1:1 programs were successfully-implemented technology initiatives. The findings from the study are divided into a primary and secondary findings section. The first of these sections is the area of primary interest for this study. That section reveals the relationship between 1:1 status and each of the three research questions. The results discussed in that section reinforce the significant findings from Chapter 4. The next section contains additional findings but they were not the primary interest of this study. The results in that section reveal teacher-level variables with statistically significant findings. It is extremely important to note that those results are not related to 1:1 status. In fact, 1:1 status can essentially be ignored when discussing those results.

Primary findings

This study was designed to reveal the impact of 1:1 programs on three research questions. Four separate multilevel models were conducted for each of the research questions. Each of the models had a unique set of variables, but each model contained 1:1 status as an independent variable. That independent variable was essentially the reason for creating this study. Propensity scores, surveys, and the multilevel model were all implemented so that the study would appropriately identify the coefficient for the 1:1 status variable. Although other variables were included in the various models, they were only included to control for other factors that may have had an impact on the dependent variables. As revealed in Chapter 4, 1:1 status proved to be very connected to each of the dependent variables in the study. Each of the twelve models used in this study, four per dependent variable, revealed a statistical significance of $p < .001$ for the 1:1 status variable. Although the coefficients did vary slightly between each of the four models created for each dependent variable, the substantive results were essentially the same. The following paragraphs describe those substantive results for each of the three research questions in this study.

Research Question 1.

Research Question 1 in this study was designed to assess whether or not students at 1:1 schools used technology more than their peers at non-1:1 schools. This question was included because the amount of time that students spend using technology is one way to gauge whether or not a 1:1 initiative has been successfully implemented. As discussed in previous chapters, in the confirmation stage of Rogers' innovation framework (2003), individuals decide whether to continue adoption of an innovation or discontinue and reject the innovation. Time is one of the two measures used in this study to assess whether or not a school's 1:1 implementation was successful. Although many might assume that simply adding technology to schools and classrooms would increase the amount of time that students spend using learning technologies, Chapter 2 highlighted how often that turns out to be a false assumption. Schools have often invested in technologies that have failed to reach wide-scale adoption or use (Cuban, 1986; Saettler, 2004). However, many educators might argue that 1:1 initiatives are unlike other previous technology initiatives. Some even claim that 1:1 programs go further than most initiatives to change schools because they are such a major change initiative (Weston & Bain, 2010).

The issue of student use of time was addressed by including a question on the survey that asked teachers how often their students used technology during the past year. Teachers were able to select their answers from a 7-point Likert scale. The responses ranged from "*Not at all*" to "*Daily*." Results from each of the models used for this question were very similar. The results indicated that teachers at 1:1 schools reported that their students used technology significantly more than students at non-1:1 schools. The coefficients for 1:1 status from the four models ranged from 1.04 to 1.14. Using the smallest of those coefficients, the results could be interpreted as follows: *On average, teachers at 1:1 schools reported scores that were 1.04 points higher than teachers at non-1:1 schools on the 7-point scale representing how much time students use technology*. When interpreting this finding, it is important to note that the dependent variable in the study is not a continuous variable. Because the time variable was an ordinal variable, it isn't possible to make a precise statement about how much more time 1:1 teachers reported that their students used technology. The more important practical interpretation is that it is quite clear that 1:1 teachers reported that their students used technology much more frequently than non-1:1 teachers. The implications of these results are discussed later in this chapter.

Research Question 2.

Research Question 2 in this study was designed to analyze whether or not 1:1 educators integrated technology differently than non-1:1 educators. The definition for integration in this study is "the extent of use of various technologies in the classroom." This dependent variable is similar to the time dependent variable from Research Question 1, but there is an important distinction. The first variable of time simply focused on how much time teachers reported that students used technology. The integration variable went beyond that and captured the use of 14 specific technology tools. To highlight the difference, consider a teacher who had students use email every day but didn't integrate any other technologies into the classroom. That teacher would have a high score for the time variable, but a low score for the integration variable. Therefore, the integration variable captures much more than just time and reflects the integration of a wide range of technologies. Those various technologies in this study included the 14 items that were used to create the integration score, which served as the dependent variable for this part of the analysis. "Q3" in Appendix E displays the items that were used to create that variable. Teachers were asked to respond to what extent they used each of the 14 items. They responded to the question on a 4-point Likert scale that ranged from "*Not at all*" to "*A large extent*." Their responses for each of the 14 items were aggregated together and then converted to a standard deviation score. This research question, like the first question, also was an indicator of whether or not teachers embraced technology. The confirmation stage of Rogers' innovation framework (2003) indicates that individuals decide to either continue to use or to reject an innovation. The results indicated that 1:1 educators were much more likely to embrace the use of technology in their classroom than their peers. The coefficient for the 1:1 status variable ranged from 0.28 to 0.32 between the four models. Using the most conservative result of 0.28, the results could be interpreted as follows: *On average, teachers at 1:1 schools reported scores that were 0.28 of a standard deviation higher than teachers at non-1:1 schools on the 4-point scale representing how much they integrated technology into their classrooms.* A more straightforward interpretation is that 1:1 educators reported much higher overall usage scores for the 14 items used for the integration dependent variable.

Technology can certainly be viewed as an innovation in schools. One way to gauge whether that innovation was embraced was to analyze the technology integration scores. The findings from this study indicate that 1:1 teachers did have higher integration scores than their non-1:1 peers. These results, along with the results from Research Question 1, indicate that 1:1 teachers are more likely to adopt technology use. This acceptance of the innovation falls into Rogers' (2003) last stage in the five-stage adoption process. Teachers at 1:1 schools are clearly using technology, in respect to time and integration, more frequently than their non-1:1 peers.

Research Question 3.

The final research question in this study attempted to address teacher technology competency in relation to 1:1 status. The research question was connected to the TPACK framework, which identified pedagogy, content, and technology knowledge as the three most important components to successful technology integration. Although this study did not analyze the pedagogy and content knowledge of educators, this question analyzed their technology knowledge. There is certainly no indication that the pedagogy or content knowledge of 1:1 teachers would be any different than their non-1:1 peers. The TPACK model would indicate that higher technology knowledge is one of three pieces to increasing integration. Therefore, increased technology knowledge, or competency, could be viewed as one piece of the three-pronged TPACK approach to increase technology integration.

The competency scores used in this study were created from two survey questions. The first survey question for competency scores (Q5) related to a teacher's skill at using technology for instruction and the second question addressed general technology use (Q8). Responses to these two questions were recorded on a 4-point Likert scale ranging from "*Not at all*" to "*Large extent*." The results indicated that teachers at 1:1 schools reported significantly higher competency scores than teachers at non-1:1 schools. The coefficient for the 1:1 status variable ranged from 0.29 to 0.35 between the four models. Using the most conservative result of 0.29, the results could be interpreted as follows: *Teachers at 1:1 schools reported technology competency scores that were 0.29 of a standard deviation higher than teachers at non-1:1 schools*. Again, the more practical interpretation is that it is quite clear that 1:1 teachers in this study reported higher technology competency scores than teachers at non-1:1 schools.

This finding may be the most surprising of all the findings in the study. Although the models take various variables into account, it could be argued that the 1:1 educators and non-1:1 educators in the study have similar backgrounds. This finding indicates that 1:1 teachers have somehow become more competent with technology than their peers. The reasons for this may be less clear. Technology competency could be higher because

1:1 schools also have made greater investments in training their teachers regarding technology integration and implementation. It is also possible that increased access to technology among 1:1 teachers increased their competency. Regardless of how or why, that increase in technology competency could be viewed as a very significant benefit of 1:1 initiatives.

Increasing teacher technology competency may be one way for schools to better prepare 21st century learners. The results of this study indicate that moving to 1:1 status is one powerful way to improve those competency levels. Although other factors were certainly part of the process that produced higher competency scores, 1:1 initiatives obviously had an impact. As schools consider the types of teachers that they want and the skill sets of those teachers, these results have important implications that are discussed in depth later in this chapter.

Secondary findings

The findings in this section were revealed in the multiple models that were created to answer the three research questions in this study. It is important to note that these results are not reported in relation to 1:1 status. These variables were included in the various models to account for possible teacher and school-level differences that may have been related to the dependent variables. The variables discussed in this section were statistically significant. The first of those sections discusses the relationship between each of the three research questions and teacher age. The next section focuses on teacher content area and the connection to each research question. The final section examines the school-level variables that were included in the models.

Age.

As mentioned previously, the time and integration variables seem quite similar. However, there are important differences between the two. Those differences may help explain the results reported in this section. The time variable was a self-reported measure of the amount of time that teachers reported that their students used technology. It did not indicate if multiple technologies were integrated in the classroom. A high time score simply indicated that technology was used frequently. The integration variable did include 14 various technologies scores that were used to create an integration score. Teachers who scored high on the integration variable reported that their students used a wide variety of technologies frequently. It is also important to note that age was reported as a dummy variable, and the *20- to 30-year-old* category was used as the reference category. Table 8 in Chapter 4 displays additional information about the age variable. With those distinctions clearly in mind, the results in this section can be more clearly understood.

There were not any significant differences regarding teacher reports of the amount of time that students use technology by teacher age. This finding may be in conflict with commonly held beliefs about the relationship between age and technology use. Many educators (and others) tend to believe that younger teachers have classes in which students use technology more frequently. This finding indicates that age is not a factor in the amount of time students use technology. However, this finding cannot be discussed without considering the results from the integration research question. Those results are reported in the following paragraph.

Teachers in the *20- to 30-year-old* category had significantly higher integration scores than their peers in each of the other four age groups. These results indicated that those teachers scored higher across the 14 items that were used to generate the integration scores. These findings may be reflective of personal learning experiences as well as the differences in the teacher training that each group experienced. Although there was a teacher training variable on the survey, it was not included in the model because it was highly correlated with the age category. That result alone may indicate that teachers' college training impacts how they integrate technology in the classroom. When interpreting the results from the first two research questions together, an interesting finding is revealed. Although age doesn't appear to have any relation to the amount of time teachers reported that their students used technology, it does have a major impact on the ways that teachers reported that their students used technology.

The final research question revealed that the *20- to 30-year-old* group had significantly higher competency scores than individuals in any of the other four age groups. As mentioned previously in reference to integration scores, this could be reflective of the different personal experiences and professional learning experiences of teachers from various age groups.

Although the age variables were not the focus of this study, these results are very consequential to educators in both 1:1 schools and non-1:1 schools. They may potentially help school leaders provide professional development that is better suited for all teachers. A more in-depth discussion of these implications occurs later in this chapter.

Content.

Additional secondary findings in the study reflected the different time, integration, and competency scores reported by teachers in different content areas. For this study, teachers were classified into nine content area categories. There was also an "Other" category that included teachers from a variety of content areas. Like the age variable, these variables were also dummy variables, with language arts used as the reference category. Again, as with the age variables, these findings are not related to a school's 1:1 status.

These results indicated that teachers in five content areas reported that their students used technology significantly less than students in language arts courses. Fine arts, foreign language, math, PE/health, and science teachers reported that their students used technology less frequently than language arts teachers. Special education teachers were the only group that reported that their students used technology more frequently than language arts teachers did. Unlike the age variables, the results from the time variable closely mirrored the results of the integration variable. All five of the content areas listed as having lower time scores also had lower integration scores. The one difference with the results from the integration models was that there was not a significant difference in integration scores between special education and language arts teachers. These results may indicate the need for certain content areas to consider additional ways to integrate technology in their classrooms.

There were also some significant differences in the technology competency scores of educators. Foreign language, math, and PE/health teachers reported lower technology competency scores than their language arts peers. Each of those three content areas also had lower time and integration scores. These findings may have very serious implications for teachers in those areas with lower scores. They may also help school leaders better take into account the unique needs of teachers in different content areas. The implications section of this chapter addresses this issue much more thoroughly.

School-level variables.

A quick glance at the school-level variables may result in the improper interpretation of the model results. For example, after glancing at the graduation rate variable in the time model, the following interpretation is likely. *As graduation rate increased by 1 percentage point, the teacher scores for time their students used technology decreased by 0.028 of a standard deviation.* However, that interpretation would be false. It is important to note that those school-level variables were from the 2007-08 school year, and the time variable was from the 2012 survey. For that reason, the interpretation above is essentially meaningless. School-level variables were included in the model *only* to account for those differences between schools in the study.

Implications for Practice and Policy

The results from this study indicate that 1:1 initiatives can be used as a lever to change schools and teachers. Each of the study variables of interest in the study - time, integration, and competency - were impacted significantly by a school's 1:1 status. The results indicate that teachers at 1:1 schools reported that their students have experiences that students at non-1:1 schools do not. The findings also indicate that 1:1 teachers develop a skill set that is different than other educators. The practical implications of these primary findings, as well as some of the additional findings, are first discussed as they pertain to school policymakers and leaders and then for teachers. Each of those sections also provide details about the primary and secondary findings discussed in the previous section.

Implications for policymakers and school leaders

This study revealed findings that have implications for 1:1 policymakers and school leaders as well as others interested in the impacts of technology in education. This section begins with a discussion of the impacts of 1:1, and concludes with a discussion of the general implications of the secondary findings that were discussed in the previous section.

1:1 implications.

The results of 1:1 status have important implications for policymakers and administrators. Numerous technology initiatives have occurred over the past century or more. However, they often have failed to be fully implemented. Film, radio, instructional television, and many computer initiatives are all examples of technology that never reached the potential that many had envisioned for them (Cuban, 1986; Saettler, 2004). A U.S. Department of Commerce (2003) report indicated that education was lagging in technology intensiveness when compared with other industry sectors. Although many barriers to technology use have been identified, one of the most common barriers is lack of resources (Hew and Brush, 2006). This study affirms how important resources are to technology use in schools. Teachers at 1:1 schools did report that their students used technology more frequently than students at non-1:1 schools. When viewed through the lens of Rogers' innovation framework (2003), this finding would indicate that 1:1 teachers accepted the innovation as evidenced by the amount of time their students used technology. Although this finding is important, it wasn't designed to evaluate the value of technology. Policymakers and school leaders must assess whether or not they believe that students should be using technology more frequently in schools. Some may not see student use of technology as an important goal of their school. However, many school leaders do want to increase the amount of time their students use technology in schools. This study indicates that 1:1 initiatives are one way to successfully increase the amount of time that students use technology. This result has very serious implications for board members and other policymakers who embrace the concept of having students using technology more frequently. Many self-proclaimed education technology enthusiasts frequently stress that providing technology is not as important to technology integration as providing appropriate training. They actually may go so far as to claim the technology itself is unimportant. This study didn't attempt to analyze which of those two components was more important. However, it did reveal that access to technology does matter. Change is often difficult for policymakers to implement. There are often roadblocks and a lack of fidelity with many change initiatives that result in failed implementation. The 1:1 initiatives in this study did successfully implement system-wide change in respect to the amount of time that teachers reported that their students used technology.

Research Question 2 in this study related to technology integration and was closely connected to Research Question 1. Like the first question, the results from this question were used as a measure to determine if 1:1 initiatives were implemented successfully. The difference between the two variables is that Research Question 1 simply reflected the time students use technology while Research Question 2 analyzed how often students used a variety of different technologies. In Chapter 2, a multitude of reasons were provided for poor technology integration at schools. Hennessy et al. (2005) described the lack of investment in learning and teaching with technology, as well as the culture where teachers work as challenges to integration. Lack of relevant knowledge, low self-efficacy, existing belief systems, and the context where teachers work were additional challenges to successful integration (Ottenbreit-Leftwich, 2010). Many schools have tried and failed to successfully improve technology integration in their classrooms. The results from this study indicate that becoming a 1:1 school is one way to successfully increase technology integration. As with the time variable, these results have serious implications for policymakers. Schools that value technology integration may consider implementing a 1:1 program as a viable solution to increase integration across a school or district. The results should not mistakenly be used to downplay other important ways to increase integration such as providing teachers with appropriate professional development. However, they do reinforce the results from other studies that report the importance of providing adequate resources (Bauer and Kenton, 2006; Hew and Brush, 2006).

Policymakers also should not overlook that this study indicated that 1:1 educators reported significantly higher technology competency scores than non-1:1 educators. As schools strive to improve technology integration, increasing teacher technology competency is one way to do that. The TPACK model identifies technology knowledge as one of the three most important factors to increase and improve technology integration. Policymakers frequently analyze ways to increase the skill set of their teachers. Although this study did not evaluate why 1:1 teachers reported higher technology competency scores, they clearly did have higher scores. It is certainly possible that those scores were higher due to the increased amount of technology professional development at 1:1 schools. It also may be possible that having classrooms full of students with computers forced teachers to become more technology savvy. Unlike non-1:1 schools, teachers at 1:1 schools were unable to simply ignore technology because they were surrounded by it every day.

Very often, decisions about becoming 1:1 are made by district officials but they certainly impact building-level leaders. Those building-level leaders need to recognize the changes that may come with the transition to becoming a 1:1 school. Results from this study indicate that teachers at 1:1 schools reported that students use technology more frequently and teachers also integrate technology more often. They also revealed that teachers reported becoming more competent with technology. Building leaders may use these findings in two important ways. The first relates to professional development. Non-1:1 principals may want to use the results from this study as a driving force to ensure that their students have increased access to technology. Their focus for professional development may include time that will increase teacher's skill level with technology. The TPACK model affirms the need for teachers' technology, pedagogy, and content knowledge. It is likely that non-1:1 educators have similar competencies around pedagogy and content knowledge. By increasing technology knowledge and its relation to the other two TPACK components, school leaders may also improve technology integration at their schools. Principals at 1:1 buildings can also use this study to guide professional development. The study findings indicate that as schools transition to a 1:1 program, it is likely that the needs of their teachers will change. Time, integration, and competency scores were all higher at 1:1 schools. Those teachers are likely to need a different type of support than teachers at non-1:1 schools. The second important way building-level leaders may use these results is through the evaluation and feedback process. The evaluation and feedback process is one way that principals demonstrate what characteristics are important to them. Non-1:1 leaders may initially want to simply focus on the amount of time that students are using technology as a tool to help increase technology use. On the other hand, 1:1 school leaders may be more concerned about how the technology is being used than how much it is used. These distinct differences certainly could impact the ways that walk-throughs, evaluations, and other feedback tools are implemented.

General implications.

The implications above were all directly related to a school's 1:1 status. They reflected recommendations and considerations for policymakers and building-level leaders when making decisions about technology in their schools. The next set of findings are not related to a school's 1:1 status. The implications are meaningful for both 1:1 and non-1:1 school leaders.

The fact that there were not significant differences in student use of technology dependent on teacher age is a very interesting point to consider. That finding indicated that providing resources and other supports may be a much more important component when considering how to increase student time using technology. However, that point should not be considered without recognizing that all age groups had integration scores that were significantly lower than the *20- to 30-year-old* group. This result indicates that age was not related to how often technology was used, but it was related to the ways that technology was used. Leaders should acknowledge that different age groups have had different personal experiences as well as educational experiences surrounding technology. Designing professional development that is differentiated would be one way to help address the unique learning needs of all teachers. These results may indicate that older teachers are not resistant to using technology in their classrooms. Instead, the results may demonstrate that they do use the technologies that they are comfortable with in their teaching. Because of their training and personal experiences, they may have had less exposure to certain technologies than younger teachers. The findings from the technology competency variable may support these implications. Those findings indicated that older teachers reported lower technology competency than the *20- to 30-year-old* group. Again, all of these results support the strong need for differentiated professional development and training for educators. School leaders who want to change the ways that their students use technology need to provide teachers with skills to use technology. The time variable seems to indicate that there isn't a feeling of apprehension among older teachers to use technology. The integration and competency variables however, may indicate that older teachers have had less training on implementing different technologies.

There were also multiple content areas that reported less time and integration with technology. Fine arts, foreign language, math, PE/health, and science teachers all had significantly lower time and integration scores than language arts teachers. When discussing these results, it is important to acknowledge that some would argue that increasing time using technology and technology integration are less important in certain content areas. For example, it is certainly feasible to believe that content areas such as PE/health, may simply have lower amounts of time that students use technology because of the nature of the discipline. Technology, at least as defined in this study, may be less important to certain disciplines. Outside of PE/health, it may be less convincing to argue that the other content areas should report that their students are using technology less frequently. These findings bring attention to the point that content area should be considered when designing professional development. Teachers should be provided with examples and experiences that are applicable to their content area. Teachers need to see models that are applicable to their content area rather than a general demonstration around technology integration.

The results around both age and content areas highlighted the need for differentiated professional development. Teacher preparation programs have certainly changed in the last 40 years. Leaders must realize that those varied experiences would impact a teacher's technology competency. The unique challenges and training for each content area are also important considerations to keep in mind when designing professional development. School leaders may believe that technology competency is less important for certain content areas and may decide against focusing on technology-oriented professional development for those educators. Other leaders may instead focus on identifying ways to help those individuals improve their technology competency. Although this study doesn't identify a correct approach, school leaders and policymakers should at least be aware of the differences that exist. These results should help school leaders better design professional development, and it should also help them as they design systems to provide feedback to educators.

Implications for teachers

The implications in this section are presented in the same way as in the previous section. Initially, those implications related directly to 1:1 status are discussed. The final portion of this section discusses the general implications that are not related to whether or not a teacher works at a 1:1 school.

1:1 teacher implications.

As teachers consider the type of environments in which they work, 1:1 programs have the potential to change the look, feel, and activity in their classrooms. Traditionally, simply adding technology has not guaranteed an increase in technology use. Ertmer (2005) noted that although technology availability has increased drastically in recent years, high-level use still is surprisingly low. The results from this study indicated that teachers in 1:1 schools reported that their students do use technology significantly more frequently than do teachers in non-1:1 learning environments. Many teachers would view that shift as positive but others may have concerns about students using technology for increased amounts of time. Teachers who teach in 1:1 schools will need to be able to design lessons that acknowledge and take advantage of students' increased use of technology.

As teachers have tried to integrate technology, there are also many challenges that they have faced. Chapter two included a discussion about many of those challenges teachers and schools have encountered while integrating technology. The literature indicated numerous teacher challenges that hindered successful integration. Those challenges included lack of training, personal characteristics, content area cultures, and "conservative teacher and school cultures" (Hennessy, Ruthven, and Brindley, 2005;

Ponticell, 2003). Hew and Brush (2006) reviewed numerous studies between 1995 and 2006 in order to identify common barriers to technology integration. The most common barrier that they identified was resources. This study highlights the importance of providing resources to improve technology integration. Teachers at 1:1 schools, who obviously have more access to technology, had much higher integration scores. Although the other barriers described in the literature are important, these findings indicate that providing resources may be one of the most effective ways to increase integration of technology.

These findings are important because they recognize that a 1:1 school may be a totally different environment in relation to technology integration and time using technology. Teachers in those technology-rich schools have new possibilities and challenges that they will face. They need to recognize that their classrooms look different than traditional classrooms. They also need to consider classroom management issues that may not be relevant to other educators. Another consideration will certainly be around the work that students do in the classroom. Educators at 1:1 schools may need to rethink their assessments along with the design of their classrooms. The TPACK model stresses the importance of the intersection of technology, pedagogy, and content knowledge. Those 1:1 teachers need to think about how pedagogy and content both interact with technology. This study revealed that 1:1 programs changed how much students used technology. It also displayed the changes in how teachers reported students used technology. These two findings need to be considered carefully when designing instruction. Non-1:1 educators also should acknowledge these findings. With a disparity in resources, they face additional challenges in order to increase the amount and ways students use technology. All of these findings indicate that 1:1 status does have an impact on schools. They also make clear that a 1:1 classroom potentially may look very different than a non-1:1 classroom.

General teacher implications.

The other important implications for teachers relate to the variables that identified certain age groups and content areas of teachers with lower time, integration, and/or competency scores. Those results may indicate that certain groups, both age and content groups, have not had the training or experiences that allow them to use technology like many other teachers have been able to do. For that reason, educators should carefully consider the type of training and workshops that they attend outside of the school environment. By participating in professional development that models effective technology use, they may be able to better use technology in their classrooms.

Because 1:1 initiatives are a school-wide initiative, the results from the study may have the largest implications for school leaders. As leaders they determine how to allocate funds, implement programs, and are forced to make decisions about the value of different initiatives. The results of this study indicated that 1:1 initiatives have had a major impact on schools. However, those results don't indicate that 1:1 initiatives are right for all schools. School leaders and policymakers must decide not only are the results from this study meaningful for their school, they also need to determine if they are worth the costs that come along with a 1:1 program. Many educators across the state of Iowa, as well as across the country, have determined that a 1:1 initiative is certainly a worthwhile investment.

Theoretical implications

This study was developed with two distinct frameworks in mind. The first two questions in this study were related to Rogers' theoretical framework and the final research question related to the TPACK model. This section highlights how the study results connected to these two frameworks.

Using digital technology in the classroom could certainly be viewed as an innovation in schools. Although all schools have implemented digital technologies in some manner, the results of those various innovations look very different. This study attempted to analyze if 1:1 schools accepted digital technologies at higher levels than their non-1:1 counterparts. Because of limitations on the data that was collected, it was not possible to analyze technology through each of Rogers' five stages. It also is likely that each school looked very different during each of those four stages. However, this study was able to analyze the confirmation stage of Rogers' innovation framework. For policy makers, that stage is certainly extremely important. Policy makers want to know whether or not their investments actually are being used in schools. Chapter 2 highlighted that many previous technology initiatives have failed to be effectively implemented. In Rogers' confirmation stage, individuals decide whether to continue adoption or discontinue and reject the innovation. This study analyzed if technology was accepted differently at 1:1 schools. The first research question used time and the second question used integration as measurement tools. Findings for both questions indicated that 1:1 educators used technology more frequently and in more ways than non-1:1 educators.

The results of the first two study questions may seem obvious to some. It is easy to assume that the results were due to the fact that students simply had more access to technology. However, more access hasn't always resulted in higher levels of use. For example, Ertmer (2005) noted that although technology availability has increased drastically in recent years, high-level use still is surprisingly low. The Iowa Department of Education (2011) reported that the 2010-2011 student to computer ratio for the state was one computer for every 2.6 students. That ratio would likely be even lower if it only included high schools. These statistics indicate that most non-1:1 teachers have easy access to technology.

The findings of this study indicated that 1:1 educators accepted and implemented technology more frequently and in different ways than their non-1:1 peers. These findings indicate that 1:1 initiatives have been 'accepted' as viewed through Rogers' framework. This may be due to the very unique nature of 1:1 initiatives. In many other technology initiatives, teachers essentially had the choice whether or not to use technology. Even in non-1:1 schools with very low student-to-computer ratios, teachers still can choose to not use technology. At 1:1 schools, every student has a computer essentially throughout the entire school day. That may be a key reason why educators no longer can choose to ignore technology. With a classroom of students with computing devices, teachers are almost forced to consider using technology in the classroom. Non-1:1 teachers certainly can choose to use technology in their classrooms, and it appears that most have easy access to technology. However, this study made it clear that they did not use technology nearly as frequently as their 1:1 peers. The study results do indicate that 1:1 educators seem to accept technology in the classroom as evidenced by the research questions regarding time and integration.

The final research question addressed whether 1:1 educators reported higher technology competency than non-1:1 educators. The TPACK model stresses the importance of pedagogy, content, and technology knowledge in order to deliver effective instruction (Harris, Mishra, & Koehler, 2009). Shulman's (1986) earlier model highlighted how teacher preparation had moved from very content-focused to very pedagogy-focused when his article was written in the 1980s. He termed the phrase pedagogical content knowledge and stressed the blending of the two areas in order to deliver more effective instruction. TPACK adds technology to Shulman's model. This study analyzed whether 1:1 educators increased their technology knowledge, but it did not address content or pedagogy knowledge. It certainly can be argued that there is no reason to believe that the content or pedagogy knowledge of 1:1 educators is different from other educators. However, this study did indicate that 1:1 educators reported higher levels of technology knowledge than non-1:1 educators. Using the TPACK model, this finding is very significant and would indicate that 1:1 educators are better able to deliver effective instruction in their classrooms because of their use of technology. As policy makers and other school leaders attempt to make changes in their schools, it appears that a 1:1 initiative may be one way to change the delivery of instruction.

Using Rogers' Diffusion of Innovation Theory and the TPACK model, this study has serious implications for policy makers. It appears that 1:1 initiatives have resulted in educators embracing or accepting a technology innovation when viewed through Rogers' framework. It also seems clear that 1:1 educators have substantially strengthened one of the three types of knowledge the TPACK model identifies as being essential to the delivery of effective instruction. These results may help policy makers as they determine whether or not to implement a 1:1 program.

Implications for Future Research

The research around 1:1 schools is very limited and frequently has involved very small samples. This study added to the body of research on 1:1 programs but there is still a major void in the literature on this topic. This section identifies numerous areas for future research as well as some of the limitations of this study.

One of the first steps in this study involved creating propensity scores so that 1:1 schools could be compared to similar non-1:1 schools. The literature on propensity scores indicated that propensity scores should be created based on the literature (Shadish and Steiner, 2010). With that in mind, those variables that the literature identified as common traits of 1:1 schools would have been used to generate the propensity scores. Unfortunately, there is not a body of research that identifies why schools make the decision to become 1:1 schools, or what those schools look like. This study did collect quantitative data that displayed differences between 1:1 schools and non-1:1 schools. However, this study did not identify why schools became 1:1 schools. A qualitative study that included interviews with 1:1 administrators and policymakers may help identify some of the reasons they made the decision to become a 1:1 school.

This study also didn't analyze the impact of professional development on 1:1 programs. Previous research has cited professional development as one of the most important components of successful 1:1 programs (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Shapley et al., 2010). Unfortunately, like much of the 1:1 research, that research is very limited. As schools strive to make their 1:1 programs successful, they want to know how to successfully implement meaningful professional development.

Future research that closely evaluates how 1:1 initiatives impact students is also needed. This study included self -reported teacher data but did not have any student level data. Observations and interviews would be two ways to begin to identify how 1:1 initiatives are impacting students. Researchers may also consider ways to evaluate the work that students are doing in 1:1 schools. Although research does exist on student achievement and student engagement, that research is also fairly limited. The studies often involve very small sample sizes and schools in their early years of 1:1 implementation.

As schools make the transition to 1:1 computing environments, they also want recommendations for successful implementation. This study lumped all 1:1 schools into one pool but there certainly are schools that have implemented 1:1 programs more successfully than others. If successful 1:1 schools can be identified, they should then be studied to identify the processes and other factors that made them successful.

Although 1:1 programs are not a new phenomenon, the research is certainly lagging. School leaders across the country are currently deciding if and how to become a 1:1 school. Their decisions will have major cost implications for their districts. In order to help school leaders make better-informed decisions, researchers have a huge task. They first need to identify if and when 1:1 implementation is successful. They then need to help identify the ways to implement 1:1 initiatives successfully. The rising number of 1:1 schools across the country should be an indication that 1:1 schools are not a fad that will disappear in the near future. It actually seems apparent that within a matter of years, 1:1 schools may become the norm rather than the exception. During this time of transition, the role that researchers play may serve as an accelerant to this rapidly spreading initiative.

Conclusion

This study was conducted to research and examine the impact of 1:1 initiatives on three different areas. These results added to a very small body of research and included a larger number of schools than most 1:1 studies to date. The investigation was conducted using data from the Iowa Department of Education, the Common Core, and teacher survey data. Although the data were disaggregated for multiple teacher and school level characteristics, the study was designed to analyze the impact of a schools 1:1 status. Those additional results were reported, but they were not the focus of this study. Those additional characteristics were instead included to account for other potential differences between the educators who responded to the survey.

This study is also unique simply because of the uncommon nature of implementing a 1:1 program. Throughout Chapter 2 various technology initiatives were discussed. Most of those technology initiatives failed to get adopted widely by teachers. A 1:1 initiative is different from previous technology initiatives in that 1:1 schools place a piece of technology in the hands of every student. Those other initiatives involved technologies that could primarily be viewed as classroom technologies or teacher-centric technologies.

The results from the 1:1 schools also were very compelling. Each of the research questions identified systematic differences between 1:1 educators and non-1:1 educators. The results for each of the questions were significant at a very high level ($p < .001$) in each of the four models. Those results for the time and integration components indicated that technology, if viewed as an innovation, was adopted successfully at the 1:1 schools. Research Question 3 identified increased teacher technology competency at 1:1 schools. That finding would indicate that those 1:1 schools could also expect increased levels of technology integration if the TPACK framework is applied.

Over the past four years, the number of 1:1 schools in the state of Iowa has exploded. That growth has occurred without much analysis of the ways that these schools have changed. This study did indicate that 1:1 schools looked substantially different from non-1:1 schools on each of the three research questions from this study. Although the literature revealed the poor results of many previous technology initiatives, 1:1 programs seem to have caused fairly quick changes in very large ways.

This study revealed that teachers reported that students at 1:1 schools used technology significantly more than peers at non-1:1 schools. The study also revealed changes in teacher behaviors. Teachers at 1:1 schools were more likely to have higher integration and technology competency scores that non-1:1 teachers. These results do indicate that the investment in 1:1 programs has resulted in some major school level changes. Like nearly any educational issue, this is a very complex issue. However, if we truly believe it is important to have students use technology more frequently in more meaningful ways, 1:1 initiatives may be one way to help achieve those goals.

School leaders are often seeking ways to make systematic changes and improvements in their schools. However, many initiatives fall short of a systems change and we see “pockets of greatness” in schools. Even in the most unsuccessful school, it is possible to find classrooms where teachers are doing amazing things. The results from this study indicate that 1:1 initiatives are one way to successfully initiate systematic change. A question for school leaders is whether or not this change is something that they want at their schools, and whether or not it is worth the cost.

APPENDIX A. VARIABLE DESCRIPITONS

Table A1

School-Level Variables

Variable	Description	Data Source
School Enrollment	Enrollment data contained the number of students in grades 9-12.	Iowa DE
% Proficient 11th Math	Percent of students in 11th grade proficient (scoring at or above the 41st percentile) in math.	Iowa DE and personal email
% Proficient 11th Reading	Percent of students in 11th grade proficient (scoring at or above the 41st percentile) in reading	Iowa DE and personal email
% Female	Enrollment data on the percentage of females in grades 9-12.	Iowa DE
% Nonwhite	Enrollment data on the percentage of ethnicities in other then white in grades 9-12.	Iowa DE
% Free and Reduced	Percentage of students that qualify for free or reduced lunch in grades 9-12.	Iowa DE
Student to Teacher Ratio	Ratio of students to teachers in grades 9-12.	Iowa DE
% ELL	Percentage of students in grades 9-12 that are English Language Learners in a district.	Iowa DE
% IEP	Percentage of students in grades 9-12 that are on Individual Educational Plans in a district.	Common Core of Data

Table A1 Continued
School-Level Variables

Variable	Description	Data Source
% Discipline Occurrences	This included in-school and out-of-school suspensions as well as expulsions as a percentage of students.	Iowa DE
Students per Computer	District data containing the number of students per computer.	Iowa DE
Graduation Rate	District data containing 4-year cohort graduation rates for students.	Iowa DE
Teacher Avg. Age	District data containing the average age of teachers for students in grades 9-12.	Iowa DE
Teacher District Experience	District data on average years of district experience in teachers in grades 9-12.	Iowa DE
Principal District Experience	Number of years of district experience of principals.	Iowa DE
Age of Principal	Average age of principals in grades 9-12 for an entire district.	Iowa DE
Superintendent District Experience	Number of years of experience in the district for superintendents.	Iowa DE
Rural	The rural variable was one of four location values for each school. Those categories were city, suburb, town, and rural and they were based on the school's physical address.	Common Core of Data

Table A1 Continued
School-Level Variables

Variable	Description	Data Source
Percent >25 with College Degree	Percent of population in the district that are 25 years or older that have a college degree. This percent includes all types of college degrees earned and is taken from the Census 2000 School Tabulation (STP2) table number P37.	Common Core of Data
Percent >16 in Labor Force	The number of individuals with employment status of in the labor force as reported on the 2000 census.	Common Core of Data
Medium Family Income	Median family income in 1999 dollars as reported on the 2000 census. The median incomes were divided by $10,000 so that results could be more easily interpreted.	Common Core of Data

Table A2

Teacher-Level Variables

Variable	Description	Data Source
Age 31-40	This is a dummy variable for age, and the *20- to 30-year-old group* is the comparison group.	Teacher survey
Age 41-50	This is a dummy variable for age, and the *20- to 30-year-old group* is the comparison group.	Teacher survey
Age 51-60	This is a dummy variable for age, and the *20- to 30-year-old group* is the comparison group.	Teacher survey
Age Over 61	This is a dummy variable for age, and the *20- to 30-year-old group* is the comparison group.	Teacher survey
Fine Arts	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey
Foreign Language	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey
Math	This is a dummy variable for content area taught, and language arts is the comparison group.	Teacher survey
PE/Health	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey
Science	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey
Soc. Studies	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey
Sp. Ed.	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey

Table A2 Continued
Teacher-Level Variables

Variable	Description	Data Source
Voc. Ed.	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey
Other	This is a dummy variable for content area taught, and *language arts* is the comparison group.	Teacher survey

APPENDIX B. MULTILEVEL MODELS

Table B1

Reported Coefficients with Integration Dependent Variable

	Coefficients			
	Model 1	Model 2	Model 3	Model 4
1:1 Status	X	X	X	X
Age 31-40	-	X	X	X
Age 41-50	-	X	X	X
Age 51-60	-	X	X	X
Age Over 61	-	X	X	X
Fine Arts	-	X	X	X
Foreign Language	-	X	X	X
Math	-	X	X	X
PE/Health	-	X	X	X
Science	-	X	X	X
Soc. Studies	-	X	X	X
Sp. Ed.	-	X	X	X
Voc. Ed.	-	X	X	X
Other	-	X	X	X
School Enrollment	-	-	X	X
Student to Teacher Ratio	-	-	X	X
Local Revenue	-	-	X	X
Avg. Principal Age	-	-	X	X
Supt. Dist. Experience	-	-	X	X
Rural	-	-	X	X
% over 16 in Labor Force	-	-	X	X
% IEP	-	-	X	X
Graduation Rate	-	-	X	X
Dist. Experience Principal	-	-	X	X
% Nonwhite	-	-	-	X
Students per Computer	-	-	-	X
% over 25 with College Degree	-	-	-	X
Median Family Income	-	-	-	X
% Prof. 11th Math	-	-	-	X
% Prof. 11th Reading	-	-	-	X
% Female	-	-	-	X
% Free and Reduced	-	-	-	X
% ELL	-	-	-	X
% Discipline Occurrences	-	-	-	X
Teacher Avg. Age	-	-	-	X
Teacher Avg. Dist. Experience	-	-	-	X

APPENDIX C. IRB LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Resear
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 11/4/2011

To: Nick Sauers
326 E 6th St
Des Moines, IA 50309

CC: Dr. Scott McLeod
N231 Lagomarcino

From: Office for Responsible Research

Title: 1:1 Laptops Implications and District Policy Considerations

IRB ID: 11-492

Study Review Date: 11/1/2011

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**
- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

APPENDIX D. DEFINITIONS

1:1: A school that provides a take-home laptop computer for every student within some grade span of the school system (e.g., every middle school student or all 11th- and 12th-graders).

Educational Technology: “Educational technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate processes and resources.” (Januszewski and Molenda, 2008 p.1)

Generalized Boosted Modeling: “A general, automated, data-adaptive algorithm that fits sever models by way of regression tree, and then merges the predictions produced by each model” (Guo & Frasier, 2010, p. 143).

Hierarchical Linear Modeling: A statistical technique that allows the research to take into account the unique nature of data collected at multiple levels.

Online learning: Learning that takes place partially or entirely over the Internet (U.S. Department of Education, 2009).

Propensity Score Matching: “The conditional probability of assignment to a particular treatment given a vector of observed covariates” (Rosenbaum & Rubin, 1983, p. 41).

Technology Integration: The extent of use of various technologies in the classroom.

APPENDIX E. TEACHER SURVEY

The survey below includes question numbers that are used only for reference purposes, and they were not viewable by participants. Because of how the survey was created, the question numbers are not in sequential order.

Teacher Technology Survey

Q37 Thanks for taking the time to take this survey. Your responses will be confidential, and you may refuse to answer any question and/or stop participating in the survey at any time. If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, 1138 Pearson Hall, Iowa State University, Ames, Iowa 50011.

Q38 What level do you teach at for most of your day?

- ❍ High School
- ❍ Middle School
- ❍ Elementary School
- ❍ Other

If High School was Selected, participants skipped to question Q1.

Q49 Do you teach high school at all?

- ❍ Yes
- ❍ No

Q1 During the previous year, about how often did you use technology as part of instruction? (e.g. the Internet, creating multimedia presentations, sending email, etc.)

- ❍ Not at all
- ❍ A few times during the year
- ❍ About once a month
- ❍ 2-3 Times a Month
- ❍ Once a Week
- ❍ A few times each week
- ❍ Daily

Q2 During the previous year, about how often did your STUDENTS use technology as part of instruction? (e.g. the Internet, creating multimedia presentations, sending email, etc.)

- ❍ Not at all
- ❍ A few times during the year
- ❍ About once a month
- ❍ 2-3 Times a Month
- ❍ Once a Week
- ❍ A few times each week
- ❍ Daily

Q5 To what extent are you skilled at using digital technology for instruction?

- ❍ Not at all
- ❍ Small extent
- ❍ Moderate extent
- ❍ Large extent

Q8 To what extent are you skilled at using digital technology in general (computers, cell phones, iPods, etc.)?

- ❍ Not at all
- ❍ Small extent
- ❍ Moderate extent
- ❍ Large extent

Q9 To what extent would you like to increase your integration of technology into your instruction?

- ❍ Not at all
- ❍ Small extent
- ❍ Moderate extent
- ❍ Large extent

Q3 To what extent do you present students in your typical class with work that involves using computers or the Internet in the following ways?

	Not at all	Small extent	Moderate extent	Large extent
Sending email	❍	❍	❍	❍
Playing educational games	❍	❍	❍	❍
Playing educational games online	❍	❍	❍	❍
Gathering pictures online	❍	❍	❍	❍
Reading information online	❍	❍	❍	❍
Creating a multimedia presentation (Ex. PowerPoint)	❍	❍	❍	❍
Using reference sites online (ex. dictionary.com)	❍	❍	❍	❍
Publishing information on a wiki or blog	❍	❍	❍	❍
Publishing information on a website	❍	❍	❍	❍
Communicating using instant messenger (IM) or other chat tools	❍	❍	❍	❍
Creating videos	❍	❍	❍	❍
Using social media (i.e. facebook)	❍	❍	❍	❍
Collaborating online with others from outside the school	❍	❍	❍	❍
Using	❍	❍	❍	❍

collaboration tools to work with other students in the school				

Q11 Please indicate the extent to which you believe the following are OBSTACLES to integrating technology into your instruction:

	Not at all	Small extent	Moderate extent	Large extent
I don't think technology is reliable	❍	❍	❍	❍
I don't know how to incorporate technology and still teach content standards	❍	❍	❍	❍
I don’t know how to use technology	❍	❍	❍	❍
I don't think technology fits my beliefs about student learning	❍	❍	❍	❍
I don't think I have enough time to prepare for using technology	❍	❍	❍	❍
I don't think I have time to integrate technology because of the amount of time required to prepare students for high stakes testing	❍	❍	❍	❍
I don't believe technology integration is useful	❍	❍	❍	❍
I think Internet text is too difficult for students to read	❍	❍	❍	❍
I don't understand copyright issues	❍	❍	❍	❍

I have difficulty controlling what information students access online	❍	❍	❍	❍
I don't know how to evaluate or assess students when they work online	❍	❍	❍	❍
I don't have time to teach students the basic computer skills needed for more complex tasks	❍	❍	❍	❍
I have difficulty managing the classroom when students are working on computers	❍	❍	❍	❍
I don't know how skilled my students are at using technology	❍	❍	❍	❍
Lack of access to technology	❍	❍	❍	❍
Lack of incentives to use technology	❍	❍	❍	❍
Lack of time during a class period	❍	❍	❍	❍
Lack of professional development on how to integrate technology	❍	❍	❍	❍
Lack of technical support	❍	❍	❍	❍
Lack of funding	❍	❍	❍	❍
Lack of support from administrators	❍	❍	❍	❍

Q16 Choose the statement below that best describes how you view technology as it relates to instruction.

- ❍ Technology should not be used in instruction.
- ❍ Technology is not important to instruction
- ❍ Technology is supplemental to instruction
- ❍ Technology is central to instruction
- ❍ I don't know.

Q17 To what extent do you feel that students benefit when they use digital technologies such as the Internet to learn in your classroom?

- ❍ Not at all
- ❍ Small extent
- ❍ Moderate extent
- ❍ Large extent

Q27 Do you feel that you have received adequate professional development on how to use technology?

- ❍ Yes
- ❍ No

Q28 Do you feel that you have received adequate professional development on the integration of digital technology into your curriculum area?

- ❍ Yes
- ❍ No

Q30 In the last academic year, have you had any professional development related to technology use?

- ❍ Yes
- ❍ No

Q31 Think about the professional development you have received to answer the following questions:

	Yes	No	Not sure
The professional development focused on how to use technology	❍	❍	❍
The professional development focused on how to integrate technology into instruction	❍	❍	❍

Q29 To what extent do you feel prepared to teach skills for your curriculum area in online environments?
- ❍ Not at all
- ❍ Small extent
- ❍ Moderate extent
- ❍ Large extent

Q21 What content area do you teach in for the majority of your day?
- ❍ Fine Arts
- ❍ Foreign Languages
- ❍ Language Arts
- ❍ Math
- ❍ Physical Education/Health
- ❍ Science
- ❍ Social Studies
- ❍ Special Education
- ❍ Vocational Education
- ❍ Other

Answer Q47 if other was selected:

Q47 Please enter the content area that you teach:

Q34 To what extent did you use technology while you were in college?
- ❍ Not at all
- ❍ Small extent
- ❍ Moderate extent
- ❍ Large extent

Q19 How many years have you been a teacher?
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10
- ❍ 11
- ❍ 12
- ❍ 13
- ❍ 14
- ❍ 15
- ❍ 16
- ❍ 17
- ❍ 18
- ❍ 19
- ❍ 20
- ❍ 21
- ❍ 22
- ❍ 23
- ❍ 24
- ❍ 25
- ❍ 26
- ❍ 27
- ❍ 28
- ❍ 29
- ❍ 30
- ❍ More than 30 years

Q20 What grade do you teach for the majority of your day?
- K
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12

Q22 What is your age?
- 20-25
- 26-30
- 31-35
- 36-40
- 41-45
- 46-50
- 51-55
- 56-60
- 61-65
- 66-70
- older than 70

Q45 Are you of Hispanic, Latino, or Spanish origin?
- No, not of Hispanic, Latino, or Spanish origin
- Yes, Mexican, Mexican Am., Chicano
- Yes, Puerto Rican
- Yes, another Hispanic, Latino, or Spanish origin

Q46 What is your race? (one or more boxes)

- ❑ White
- ❑ Black, African Am., or Negro
- ❑ American Indian or Alaska Native
- ❑ Asian Indian
- ❑ Chinese
- ❑ Filipino
- ❑ Other Asian
- ❑ Japanese
- ❑ Korean
- ❑ Vietnamese
- ❑ Native Hawaiian
- ❑ Guamanian or Chamorro
- ❑ Samoan
- ❑ Other Pacific Islander

Q36 Where do you teach?

- ❍ Abraham Lincoln High School
- ❍ Adair-Casey Jr-Sr High School
- ❍ ADM Senior High School
- ❍ AGWSR High School
- ❍ A-H-S-T High School
- ❍ Akron Westfield Senior High School
- ❍ Albia High School
- ❍ Alburnett Junior-Senior High School
- ❍ Algona High School
- ❍ Alta Senior High School
- ❍ Ames High School
- ❍ Anamosa High School
- ❍ Ankeny High School
- ❍ Aplington Parkersburg High School
- ❍ Armstrong-Ringsted High School
- ❍ Atlantic High School
- ❍ Audubon Middle-High School
- ❍ Ballard Community Senior High School
- ❍ Battle Creek-Ida Grove Senior High School
- ❍ Baxter High School
- ❍ BCLUW High School
- ❍ Bedford High School
- ❍ Belle Plaine Jr/Sr High School
- ❍ Bellevue High School
- ❍ Belmond-Klemme Community Jr-Sr High School
- ❍ Benton Community Senior High School
- ❍ Bettendorf High School
- ❍ Bondurant-Farrar High School
- ❍ Boone High School
- ❍ Boyden-Hull High School
- ❍ Boyer Valley Middle/High School
- ❍ Brooklyn-Guernsey-Malcom Jr-Sr High School
- ❍ Burlington Community High School
- ❍ CAL Community High School
- ❍ Calamus-Wheatland Sec Attendance Center
- ❍ CAM High School
- ❍ Camanche High School
- ❍ Cardinal Middle-Senior High School

- Carlisle High School
- Carroll High School
- Cascade Junior-Senior High School
- Cedar Falls High School
- Center Point-Urbana High School
- Centerville High School
- Central City High School
- Central Community Jr-Sr High School
- Central Decatur MS/Sr High School
- Central High School
- Central High School
- Central Lee High School
- Central Lyon Senior High School
- Central Springs High School
- Chariton High School
- Charles City High School
- Charter Oak-Ute High School
- Clarinda High School
- Clarion-Goldfield HS
- Clarke Community High School
- Clarksville High School
- Clay Central-Everly JR. SR. High School
- Clayton Ridge High School
- Clear Creek Amana High School
- Clear Lake High School
- Clinton High School
- Colfax-Mingo High School
- Collins-Maxwell Middle/High School
- Colo-NESCO Jr./Sr. High Learning Center
- Columbus Community High School
- Corning High School
- Corwith-Wesley High School
- Creston High School
- Crestwood High School
- Dallas Center-Grimes High School
- Danville Junior-Senior High School
- Davis County Community High School
- Decorah High School
- Denison High School

- Denver Senior High School
- Des Moines Central Campus High School
- Diagonal Junior-Senior High School
- Dike-New Hartford High School
- Dubuque Senior High School
- Dunkerton High School
- Durant High School
- Eagle Grove High School
- Earlham Senior High School
- East Buchanan High School
- East Central Community High School
- East High School
- East High School
- East High School
- East Marshall Senior High School
- East Mills High School
- East Sac County High School
- East Union Middle-High School
- Eddyville-Blakesburg Junior - Senior High
- Edgewood-Colesburg High School
- Eldora-New Providence High School
- Elk Horn-Kimballton High School
- Emmetsburg High School
- English Valleys Jr-Sr High School
- Essex Junior-Senior High School
- Estherville Lincoln Central High School
- Fairfield High School
- Forest City High School
- Fort Dodge High School
- Fort Madison High School
- Fremont-Mills Middle And Senior High School
- Galva-Holstein High School
- Garner-Hayfield High School
- George Washington High School
- George-Little Rock Senior High School
- Gilbert High School
- Gladbrook-Reinbeck High School
- Glenwood Senior High School
- Glidden-Ralston Jr-Sr High School

- GMG Secondary School
- Graettinger-Terril High School
- Grand Junction High School
- Grinnell Community Senior High School
- Griswold Middle/High School
- Grundy Center High School
- Guthrie Center High School
- Hampton-Dumont High School
- Harlan Community High School
- Harmony Jr. Sr. High
- Harris-Lake Park High School
- Hartley-Melvin-Sanborn High School
- Hempstead High School
- Highland High School
- Hinton High School
- H-L-V Junior-Senior High School
- Hoover High School
- Hudson High School
- Humboldt High School
- IKM-Manning High School
- Independence Junior Senior High School
- Indianola High School
- Interstate 35 High School
- Iowa City High School
- Iowa Falls - Alden High School
- Iowa Valley Jr-Sr High School
- Janesville Junior-Senior High School
- Jefferson-Scranton High School
- Jesup High School
- John F Kennedy High School
- John R Mott High School
- Johnston Senior High School
- Kee High School
- Keokuk High School
- Keota High School
- Kingsley-Pierson High School
- Knoxville High School
- Lake Mills Senior High School
- Lamoni High School

- Laurens-Marathon High School
- Lawton Junior-Senior High School
- Le Mars High School
- Lenox High School
- Lewis Central Senior High School
- Lincoln High School
- Linn-Mar High School
- Lisbon High School
- Logan-Magnolia Jr-Sr High School
- Lone Tree Junior-Senior High School
- Louisa-Muscatine High School
- Lynnville-Sully High School
- Madrid High School
- Manson Northwest Webster Junior High/High School
- Maple Valley-Anthon Oto High School
- Maquoketa Community High School
- Maquoketa Valley Senior High School
- Marcus-Meriden-Cleghorn Jr/Sr High School
- Marion High School
- Marshalltown High School
- Martensdale-St Marys Jr-Sr High School
- Mason City High School
- Mediapolis High School
- Melcher-Dallas High School
- MFL Marmac HS
- Midland Middle/High School
- Mid-Prairie High School
- Missouri Valley High School
- MOC-Floyd Valley High School
- Montezuma High School
- Monticello High School
- Moravia High School
- Mormon Trail Jr-Sr High School
- Moulton-Udell High School
- Mount Ayr High School
- Mount Pleasant High School
- Mount Vernon High School
- Murray School Murray Jr/Sr High
- Muscatine High School

- Nashua-Plainfield High School
- Nevada High School
- New Hampton High School
- New London Jr-Sr High School
- Newell-Fonda High School
- Newton Senior High School
- Nishnabotna High School
- Nodaway Valley High School
- North Butler High School
- North Cedar High School
- North Fayette High School
- North High School
- North High School
- North High School
- North Iowa High School
- North Mahaska Jr-Sr High School
- North Polk High School
- North Scott Senior High School
- North Tama High School
- Northeast Hamilton High School
- Northeast Middle-High School
- North-Linn Senior High School
- Northwood-Kensett Jr-Sr High School
- Norwalk Senior High School
- NSK High School High School
- Oelwein High School
- Ogden High School
- Okoboji High School
- Olin Junior-Senior High School
- Orient-Macksburg Senior High School
- Osage High School
- Oskaloosa High School
- Ottumwa High School
- Panorama High School
- Paton-Churdan Jr-Sr High School
- PCM High School
- Pekin Community High School
- Pella High School
- Perry High School

- Pleasant Valley High School
- Pleasantville High School
- Pocahontas Area High School
- Prairie High School
- Prairie Valley High School
- Preston High School
- Red Oak High School
- Remsen-Union High School
- Riceville High School
- River Valley Junior- Senior High School
- Riverside Community High School
- Rock Valley Jr-Sr High School
- Rockford Junior-Senior Rockford Senior High
- Roland-Story High School
- Roosevelt High School
- Ruthven-Ayrshire High School
- Saydel High School
- SCC High School
- Sergeant Bluff-Luton Senior High School
- Seymour High School
- Sheldon High School
- Shenandoah High School
- Sibley-Ocheyedan High School
- Sidney High School
- Sigourney Jr-Sr High Sch
- Sioux Center High School
- Sioux Central High
- Solon High School
- South Hamilton Middle And High School
- South O'Brien Secondary School
- South Page Senior High School
- South Tama County High School
- South Winneshiek High School
- Southeast Polk High School
- Southeast Warren Jr-Sr High School
- Southeast Webster-Grand High School
- Spencer High School
- Spirit Lake High School
- Springville Secondary School

- St Ansgar High School
- Stanton High School
- Starmont High School
- Storm Lake High School
- Sumner-Fredericksburg HS
- Thomas Jefferson High School
- Thomas Jefferson High School
- Tipton High School
- Treynor Middle School / High School
- Tri-Center High School
- Tri-County High School
- Tripoli Middle/Sr High School
- Turkey Valley Jr-Sr High School
- Twin Cedars Jr-Sr High School
- Underwood High School
- Union High School
- Urbandale High School
- Valley High School
- Valley High School
- Valley Southwoods
- Van Buren Community High School
- Van Meter Jr-Sr High School
- Ventura Jr-Sr High School
- Villisca Community High School
- Vinton-Shellsburg High School
- WACO High School
- Walnut High School
- Wapello Senior High School
- Wapsie Valley High School
- Washington High School
- Washington High School
- Waukee Senior High School
- Waukon High School
- Waverly-Shell Rock Senior High School
- Wayne Community Jr-Sr High School
- Webster City High School
- West Bend-Mallard High School
- West Branch High School
- West Burlington High School

- West Central Jr-Sr High School
- West Central Valley High School
- West Delaware High School
- West Fork High School
- West Hancock High School
- West Harrison High School
- West High School
- West High School
- West High School
- West Liberty High School
- West Lyon High School
- West Marshall High School
- West Monona High School
- West Senior High School
- West Sioux High School
- Western Dubuque High School
- Westside Junior-Senior High School
- Westwood High School
- Whiting Senior High School
- Williamsburg Jr-Sr High School
- Wilton Jr-Sr High School
- Winfield-Mt Union Jr-Sr High School
- Winterset Senior High School
- Woodbine High School
- Woodbury Central High School
- Woodward-Granger High School
- Other

Individuals only answered the next question, if they selected “Other”.

Q48 Please enter the name of the school where you teach:

REFERENCES

Anglin, G. J. (Ed.). (2011). *Instructional technology : Past, present, and future.* Santa Barbara, California: Libraries Unlimited.

Aslan, S., & Reigeluth, C. M. (2011). A trip to the past and future of educational computing: Understanding its evolution. *Contemporary Educational Technology, 2*(1), 1-17.

Bauer, J., & Kenton, J. (2005). Toward technology integration in the schools: Why it isn't happening. *Journal of Technology and Teacher Education, 13*(4), 519-546.

Bain, A., & Weston, M. E. (2009). The future of computers and 1:1 laptop initiatives: Which side of the border are you on? *Independent School, 68*(2), 50-56.

Bebell, D. (2005). Technology promoting student excellence: An investigation of the first year of 1:1 computing in New Hampshire middle schools: Technology and Assessment Study Collaborative.

Bebell, D., & Kay, R. (2010). One to one computing: A summary of the quantitative results from the Berkshire Wireless Learning Initiative. *Journal of Technology, Learning, and Assessment, 9*(2).

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. *Journal of Technology, Learning, and Assessment, 9*(1).

Becker, H. J. (2000). Findings from the teaching, learning, and computing survey: Is Larry Cuban right? *Education Policy Analysis Archives, 8*(51).

Berry, A. M., & Wintle, S. E. (2009). Using laptops to facilitate middle school science learning: The results of hard fun: Maine Education Policy Research Institute.

Best, S., & Krueger, B. S. (2004). *Internet data collection*. Thousand Oaks, CA: Sage.

Bianchi, W. (2008). Education by radio: America's schools of the air. *TechTrends, 52*(2), 36-44.

Bryk, A. S., & Raudenbush, S. W. (1992). *Hierarchical linear models*. Newbury Park, CA: Sage Publications.

Burns, K., & Polman, J. (2006). The impact of ubiquitous computing in the Internet age: How middle school teachers integrated wireless laptops in the initial stages of implementation. *Journal of Technology and Teacher Education, 14*(2), 363-385.

Christensen, C., Johnson, C. W., & Horn, M. B. (2008). *Disrupting class: How disruptive innovation will change the way the world learns* (First ed.). New York, NY: McGraw-Hill.

Cosmann, R. (1996). The evolution of educational computer software. *Education, 116*(4).

Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920*. New York, N.Y.: Teachers College Press.

D'Agostino, R. B. (1998). Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Statistics in Medicine. 17*(19), 2265-2281.

Dawson, C., & Rakes, G. C. (2003). The influence of principals' technology training on the integration of technology into schools. [Article]. *Journal of Research on Technology in Education, 36*(1), 29-49.

Dawson, K., Cavanaugh, C., & Ritzhaupt, A. D. (2006). Florida's EETT Leveraging Laptops Initiative and its impact on teaching practices. *Journal of Research on Technology in Education, 41*(2), 143-159.

Dockstader, J. (1999). Teachers of the 21st century know the what, why, and how of technology integration. *T.H.E. Journal, 26*(6), 73-74.

Douglas, G. H. (1987). *The early days of radio broadcasting*. Jefferson, North Carolina:

McFarland & Company, Incorporated Publishers.

Drayton, B., Falk, J. K., Stroud, R., Hobbs, K., & Hammerman, J. (2010). After installation: Ubiquitous computing and high school science in three experienced, high technology schools. *Journal of Technology, Learning, and Assessment, 9*(3), 4-56.

Dunleavy, M., & Heinecke, W. F. (2008). The impact of 1:1 laptop use on middle school math and science standardized test scores. *Computers in the Schools, 24*(3-4), 7-22.

Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned. *Educational Leadership, 51*(7), 4-10.

Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *Educational Technology, 42*(1), 5-13.

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47-61.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25-40.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255-284.

Fan, X., & Nowell, D. L. (2011). Using propensity score matching in educational research. *Gifted Child Quarterly, 55*(1), 74-79.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference*. (4th ed., 11.0 Update). Boston: Allyn & Bacon

Groves, R. M., Fowler Jr., F. J., Couper, M. P., Lepkowski, J., M., Singer, E., & Tourangeau, R.

(2003). *Survey methodology* (2nd ed.). Hoboken, New Jersey: John Wiley & Sons, Inc.

Gulek, J. C., & Demirtas, H. (2005). Learning with technology: The impact of laptop use on student achievement. *ERS Spectrum*, *23*(4), 4-20.

Guo, S., & Fraser, M. W. (2010). *Propensity score analysis* (Vol. 11). Los Angeles, CA: Sage Publications.

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education, 41*(4), 393-416.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies*, *37*(2), 155-192.

Hew, K. F., & Brush, T. (2006). Integrating technology into k-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, *55*(3), 223-252.

Hu, W. (2007, May 4). Seeing no progress, some schools drop laptops, *The New York Times*. Retrieved from http://www.nytimes.com/2007/05/04/education /04laptop.html?pagewanted=all

Hughes, J. E., Kerr, S. P., & Ooms, A. (2005). Content-focused technology inquiry groups: Cases of teacher learning and technology integration. *Journal of Educational Computing Research*, *32*(4), 367-379.

Hutchinson, A., & Reinking, D. (2011). Teachers' perceptions of integrating information and communication technologies into literacy instruction: A national survey in the United States. *Reading Research Quarterly, 46*(4), 312-333. doi: 10.1002/RRQ.002

Iowa Department of Education. (2007). Data and Statistics [Tables of student and school characteristics]. Retrieved from http://educateiowa.gov/index.php?option =com_docman&Itemid=4434

Iowa Department of Education. (2012). *Education Statistics* [Data file]. Retrieved from http://educateiowa.gov/index.php?option=com_content&view=article&id=346&Itemid =4431

Januszewski, A., & Molenda, M. (2008). *Educational technology: A definition with commentary*. New York, NY: Lawrence Erlbaum Associates.

Kypri, K., Gallagher, S. J., & Cashell-Smith, M. L. (2004). An Internet-based survey method for college student drinking research. *Drug and Alcohol Dependence*, *76*(1), 45-53.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575-614.

Lei, J., & Zhao, Y. (2008). One-to-one computing: What does it bring to schools? *Journal of Educational Computing Research*, *39*(2), 97-122.

Lemke, C., & Martin, C. (2004a). One to one computing in Michigan: A state profile. Metiri Group.

Lemke, C., & Martin, C. (2004b). One-to-one computing in Indiana: A state profile. Metiri Group.

Light, D., McDermott, M., & Honey, M. (2002). Project Hiller: The impact of ubiquitous portable technology on an urban school. New York: Center for Children and Technology, Education Development Center.

Lowther, D. L., Ross, S. M., & Morrison, G. M. (2003). When each one has one: The influences on teaching strategies and student achievement of using laptops in the classroom. *Educational Technology Research and Development, 51*(3), 23-44.

Mertler, A., Vannatta, A. V. (2010). *Advanced and Multivariate Statistical Methods* (4th ed.). Glendale, CA: Pyrczak Publishing.

Metiri Group. (2006). 1:1 learning: Apple Computer, Inc. Retrieved from http://www.k12blueprint.com/k12/blueprint/cd/1_to_1_white_paper.pdf

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Mouza, C. (2008). Learning with laptops: Implementation and outcomes in an urban, under-privileged school. *Journal of Research on Technology in Education, 40*(4), 447-472.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Journal of information technology for teacher education, 9*(3), 319.

National Center for Education Statistics. (2007). *Common core of data* [Tables of student and school characteristics]. Retrieved from http://nces.ed.gov /ccd/bat/

National Center for Education Statistics. (2010). *Number and internet access of instructional computers and rooms in public schools, by selected school characteristics*: Selected years, 1995 through 2008 [Table 108]. Retrieved from http://nces.ed.gov/programs/digest/d10/tables/dt10_108.asp

National Center for Education Statistics. (2012) *Common core of data* [Data file]. Retrieved from http://nces.ed.gov/ccd/bat/index.asp

Olsen, J. R., & Bass, V. B. (1982). The application of performance technology in the military: 1960-1980. *Performance and Instruction, 21*(6), 32-36.

Papert, S. (1984). Trying to predict the future. *Popular Computing*, 30-44.

Penuel, W. R. (2006). Implementation and effects of one-to-one computing initiatives: A research synthesis. *Journal of Research on Technology in Education, 38*(3), 329-348.

Peytchev, A. (2009). Survey breakoff. *The Public Opinion Quarterly*, *73*(1), 74-97.

Picciano, A. G., & Seaman, J. (2007). K-12 online learning: A survey of U.S. School district administrators: Sloan Consortium.

Ponticell, J. A. (2003). Enhancers and inhibitors of teacher risk taking: A case study. *Peabody Journal of Education, 78*(3), 5-24.

Porter, S. R., & Whitcomb, M. E. (2003). The impact of contact type on web survey response rates. *The Public Opinion Quarterly*, *67*(4), 579-588.

Project Red (2010). *The technology factor: Nine keys to student achievement and cost-effectiveness.* MDR. Greaves, T., Hayes, J., Wison, L., Gielniak, M., & Peterson, R.

Rakes, G. C., Fields, V. S., & Cox, K. E. (2006). The influence of teachers' technology use on instructional practices. *Journal of Research on Technology in Education, 38*(4), 409-424.

Reiser, R. A. (2001). A history of instructional design and technology: Part 1: A history of instructional media. *Educational Technology, Research and Development, 49*, 53-64.

Rockman, S. (2003). Learning from laptops. *Threshold Magazine*, *1*(1), 24-28.

Rogers, E.M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41-55.

Rubin, D. B., & Thomas, N. (1996). Matching using estimated propensity scores: Relating theory to practice. *Biometrics, 52*(1), 249-264.

Russell, M., Bebell, D., & Higgins, J. (2004). Laptop learning: A comparison of teaching and learning in upper elementary classrooms equipped with shared carts of laptops and permanent 1:1 laptops. *Journal of Educational Computing Research, 30*(4), 313-330.

Saettler, P. (2004). *The evolution of American educational technology*. Greenwich, CT: Information Age Publishing.

Schudde, L. T. (2011). The causal effect of campus residency on college student retention. *Review of Higher Education, 34*(4), 581-610.

Selwyn, N. (1999). Differences in educational computer use: The influence of subject cultures. *The Curriculum Journal, 10*(1), 29-48.

Shadish, W. R., & Steiner, P. M. (2010). A primer on propensity score analysis. *Quantitative Research Methodology, 10*(1), 19-26.

Shapley, K., Sheehan, D., Sturges, K., Caranikas-Walker, F., Huntsberger, B., & Maloney, C. (2006). Evaluation of the Texas technology immersion pilot: Texas Center for Educational Research.

Shapley, K. S., Sheehan, D., Sturges, K., Caranikas-Walker, F., Huntsberger, B., & Maloney, C. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *Journal of Technology, Learning, and Assessment, 9*(4).

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Siegle, D., & Foster, T. (2000). *Effects of laptop computers with multimedia and presentation software on student achievement*. Paper presented at the Annual Meeting of the American

Eduation Research Association, New Orleans, LA.

Silvernail, D. L., & Gritter, A. K. (2007). Maine's middle school laptop program: Creating better writers: University of Southern Maine.

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. [Article]. *Personnel Psychology, 59*(3), 623-664. doi: 10.1111/j.1744-6570.2006.00049.x

Slinker, B. K., & Glantz, S. A. (1985). Multiple regression for physiological data analysis: The problem of multicollinearity. *American Journal of Physiology - Regulatory, Integrative and Comparative Physiology, 249*(1), R1-R12.

Smith, H. L. (1997). Matching with multiple controls to estimate treatment effects in observational studies. *Sociological Methodology, 27*, 325-353.

Snider, R. C. (1992). The machine in the classroom. *Phi Delta Kappan, 74*(4), 316-323.

Snijders, T., & Bosker, R. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Thousand Oakes, CA: Sage Publications.

Snyder, T. D., & Dillow, S. A. (2011). *Digest of education statistics, 2010. NCES 2011-015*. National Center for Education Statistics. Retrieved from http://search.ebscohost.com /login.aspx?direct=true&db=eric&AN=ED518987&site=ehost-live

Stevens, J. (2001). *Applied multivariate statistics for the social sciences* (4th ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Straub, E. T. (2009). Understanding technology adoption: Theory and future directions for informal learning. *Review of Educational Research, 79*(2), 625-649.

Suhr, K. A., Hernandez, D. A., Grimes, D., & Warschauer, m. (2010). Laptops and fourth-grade literacy: Assisting the jump over the fourth-grade slump. *Journal of Technology,* *Learning, and Assessment, 9*(5), 4-45.

Taylor, R., & Chonacky, N. (1982). Computer in the school: Tutor, tool, tutee. *American Journal of Physics, 50*, 91.

Taylor, R. P. (2003). Reflections on the computer in school. [Online serial]. *Contemporary Issues in Technology and Teacher Educatoin, 3*(2).

Technology. (n.d.) . In Merriam-Webster's online dictionary. Retrieved from http://www.Merriam-webster.Com/dictionary/technology.

U.S. Department of Commerce, Economics and Statistics Administration. (2003). *Digital economy*. Washington, D.C.: Retrieved from http://www.esa.doc.gov/sites/default/files /reports/documents /dig_econ_2003.pdf

U.S. Department of Education. (2009). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Retrieved from www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf

Wagner, T. (2008). *The global achievement gap: Why even our best schools don't teach the new survival skills our children need--and what we can do about it*. New York: Basic Books.

Warschauer, M., & Grimes, D. (2005). First year evaluation report Fullerton School District Laptop Program: University of California, Irvine.

Watson, J., Murin, A., Vashaw, L., Gemin, B., & Rapp, C. (2011). Keeping pace with k-12 online learning: An annual review of policy and practice: Evergreen Educaiton Group.

Weston, M. E., & Bain, A. (2010). The end of techno-critique: The naked truth about 1:1 laptop initiatives and educational change. *Journal of Technology, Learning, and Assessment, 9*(6).

Zucker, A. A., & McGhee, R. (2005). A study of one-to-one computer use in mathematics and science instruction at the secondary level in Henrico county public schools: SRI International and Education Development Center.