2016

How Technology Supported Teacher Behaviors Impact Student Outcomes: Results from a 1:1 Computing Initiative

James Siddall
University of South Carolina

How Technology Supported Teacher Behaviors Impact Student Outcomes:
Results from a 1:1 Computing Initiative

by

James Siddall

Bachelor of Arts
Washington University in St. Louis, 2011

Master of Arts
University of South Carolina, 2013

Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy in

School Psychology

College of Arts and Sciences

University of South Carolina

2016

Accepted by:

Abraham Wandersman, Major Professor

Kimberly H. Hills, Committee Member

Mark Weist, Committee Member

Robert Johnson, Committee Member

Lacy Ford, Senior Vice Provost and Dean of Graduate Studies

DEDICATION

I dedicate this project to my parents and family who have supported me throughout the years and helped me to get where I am today.

ACKNOWLEDGEMENTS

Thank you to all the people who helped in the conceptualization and execution of this project. I would like to thank Andrea Lamont, Ph.D., for all of her work in helping me with my data analysis. I would also like to acknowledge the contributions of Abraham Wandersman, Ph.D., Pam Imm, Ph.D., Annie Wright, Ph.D., Robert Markle, M.A., Brittany Skiles Cook, M.A., Michelle Abraczinskas, M.A., Shirley Smith, and Gail Bienstock.

ABSTRACT

As computing technology has advanced over the last several decades, many schools and school districts have embraced the use of this technology in education. One way in which schools and school districts have adopted computing technology is through adopting 1:1 computer initiatives where each student is provided with a computing device. However, despite the widespread and continuously expanding use of 1:1 computer initiatives within the educational setting, surprisingly little is known about the classroom-level factors that may impact student educational outcomes. Only one study to date (Shapley et al., 2010) has attempted to investigate specific classroom-level factors that may impact student outcomes within a 1:1 initiative. Therefore, the current study examined the impact of specific, technology-supported teaching strategies (personalized learning, authentic learning, and computer-supported collaborative learning) on students' school satisfaction, academic outcomes, and 21st century skills. The study was conducted on a dataset consisting of approximately 8, 047 students and 517 teachers in grades 3-8 from a Southeastern school district that implemented a 1:1 technology initiative. The students surveyed provided information about their overall school satisfaction as well as their perceptions of their teachers' use of the personalized, authentic, and computer-supported collaborative teaching strategies and overall levels of computer use in the classroom. The teachers also supplied their perceptions of their own use of these strategies. A subsample of students also participated in an assessment of their 21st century

learning skills. In order to examine the potential for school-wide impacts on student outcomes, models were run with school-level variables that included school-wide levels of students' perceptions of teachers' use of technology-supported teaching strategies, school-wide levels of teachers' perceptions of their own use of these strategies, as well as school-wide measures of 1:1 implementation quality. Study 1 examined the impact of the technology-supported teaching strategies mentioned above on students' school engagement and academic outcomes. Multi-level analyses revealed that students' perceptions of their teachers' use of personalized and authentic learning strategies had a significant, positive relationship with students' school engagement. Results also indicated that students' perceptions of their teachers' use of authentic learning strategies was significantly positively related to greater gains in English/Language Arts as well as Mathematics achievement scores. In addition to students' perceptions of their own teachers' use of authentic learning strategies in the classroom, it was also found that schools with higher overall levels of this perception also had greater gains in Mathematics achievement scores. Higher levels of computer use in the classroom were also found to be positively related to gains in students Mathematics achievement scores. In addition, it was found that school-wide levels of quality professional development were also associated with greater gains in students' Mathematics achievement scores. However, results also revealed that greater use of computer-supported collaborative learning strategies was associated with lower levels of school satisfaction and weaker gains in Mathematics achievement scores. Study 2 examined the relationship of students' perceptions of their teachers' use of technology-supported teaching strategies on students' 21st century learning skills. Results revealed that students' reports of their teachers' use of computer-supported collaborative learning strategies was consistently related to lower scores on this measure in the elementary sample (5^{th} grade), but not in the middle school sample (8^{th} grade). Taken together, these findings support several positive impacts of the technology-supported teaching strategies examined, but also highlight the need to investigate technology-related teaching strategies in a more nuanced manner as not all technology-supported teaching strategies necessarily have the positive impacts that have been theorized.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

The last decade has seen an increased proliferation in the use of computer technology in education. Ever since the 1980s, the positive effects of computer technology use in education have been documented in several formal and informal research studies examining its impact on such wide-ranging outcomes as cognitive abilities, academic achievement, engagement, and numerous others (O'Dwyer et al., 2008). Despite the increasing use of technology in education, many questions posed over a decade and a half ago still remain, especially in regards to student achievement. In a 1999 U.S. Department of Education conference (as recounted by McNabb, Hawkes, and Rouk, 1999, p.1), it was reported that "Parents and teachers, school boards and administrators, governors and state legislatures, and Congress all want to know if the nation's investment in technology is providing a return in student achievement. Indeed, if resources are to be expended on technology, it is becoming a political, economic, and public policy necessity to demonstrate its vital effectiveness". The need for more information regarding the impact of technology use and technology initiatives continues to be a necessity as an increasing number of schools, districts, and states continue to move toward significantly increasing their use of technology in the classroom.

As technology has continued to become cheaper and more readily available, many schools, districts, and states have decided to implement 1:1 technology initiatives (where a device is provided to every student) to increase the use of technology in their schools and possibly improve educational outcomes. Since one of the most widely known 1:1 computer initiatives began in Maine in 2001, many such initiatives have sprung up across the United States in states such as Georgia, Florida, Maine, Massachusetts, Michigan, Missouri, New Hampshire, Pennsylvania, South Carolina, and South Dakota as well as in several foreign countries, including Spain, Portugal, Germany, Italy, Turkey, and the UK (Holcomb, 2009; Fleischer, 2012). However, although these initiatives are becoming increasingly widespread, studies have yet to show the robust, positive outcomes that many 1:1 proponents have hoped for.

Although 1:1 initiatives continue to spread in popularity, many have criticized the programs for their high cost and relatively small effects reported thus far (Cuban, 2001). Larry Cuban, a respected voice in education, has provided very pointed commentary against 1:1 computing initiatives, and in many ways his critiques largely sum up the main arguments leveled against the proponents of 1:1 computing initiatives. Cuban's main critiques are twofold: 1. He states that although advocates for 1:1 initiatives believe simply equipping teachers and students with computers will revolutionize teaching and learning, this claim is largely unsubstantiated and 2. He maintains the belief that academic achievement gains are much more likely to emerge from innovative teaching practices than from the increased use of computer technology in schools (2006). As evidence of the growing dissatisfaction with the results of 1:1 computing, Hu (2007) has reported that many schools have begun abandoning their programs after they failed to find the expected gains and experienced heavy costs. However, reasons for these apparent failures are sorely lacking. As Fleischer (2012) commented in his review of the literature surrounding 1:1 initiatives, "a sufficient body of knowledge about how to gain the most from one-to-one computing projects may also be lacking. The reasons for unsuccessful implementation projects remain, as of yet, largely unanswered” (p. 3).

In a rebuttal to Cuban and other critics, Weston and Bain (2010) assert that a major reason many have failed to see their expected gains is because of their inability to see the computers as a tool and instead have chosen to see the use of computers as an innovation in itself. They contend that the relative popularity of these initiatives is actually an opportunity waiting to be seized- that these initiatives can possibly be leveraged to change teaching and learning at a scale that many other innovations have failed to achieve. They make the comparison to other technologies used in other professions, such as an arthroscope used by a surgeon or computer-assisted design software being used by an engineer. These technologies have been able to revolutionize the process through which these professionals do their jobs, but they are used as a means to an end, rather than seen as an end in themselves where individuals are handed the devices and asked to create possible uses for them. This is where they see the biggest problem with 1:1 computing initiatives- that no paradigm yet exists within the educational sphere or 1:1 computing models that comprehensively demonstrates how the computers should be used to enhance educational outcomes. Instead, the computers are often used as replacements- physical books replaced by e-books, chalkboards replaced with Smart boards, etc. They believe educators should follow the lead of other professions and let the form and function of usage drive access, not expect it to work the other way around.

Despite this call for the development and study of specific mechanisms that can drive positive outcomes related to 1:1 initiatives, to date a vast majority of the studies have either examined the potential impact of very specific computer-based interventions or simply tried to compare the outcomes of students in 1:1 initiatives to students not in these initiatives. As can be seen in Weston and Bain's (2010) critique, both of these approaches are inadequate if we are to understand how we can use technology in order to improve student outcomes. While the results thus far have generally shown modest improvements in student outcomes associated with increased computer access and use, much more research is required in order to find and illuminate the mechanisms that can lead to ever more substantial changes.

The following pages will summarize some of the research to date from both the narrow perspective of individual interventions as well as the broad approach of examining the impact of technology access and use on student outcomes. After these outcomes are covered, this paper will describe the research surrounding some potential technology- supported teaching strategies that may have promise as possible mechanisms to promote positive changes in student outcomes within a 1:1 initiative. However, as will be discussed later on, we cannot simply expect that changes in teaching strategies will directly impact student academic outcomes. One way to examine the impact of these practices is to examine the potential for them to impact student engagement and therefore the literature surrounding students' school engagement, specifically their school satisfaction, will be discussed. Following that discussion will be a discussion of 21st century skills and how we may possibly use them to better understand the potential impact of increased technology use on students' real-world skills in addition to their academic achievement as measured by state-required standardized tests.

1.1 Small-Scale Technology Studies

As mentioned above, one method investigators have used to examine the potential role of computer technology in education has been to examine the impact of computer-based interventions on various student-level outcomes. A major limitation of this approach has been that a large majority of these studies have employed very small, non-representative samples and that the classrooms usually receive an extremely high level of support not commonly found in most schools. In addition, many of these studies used tools developed by the researchers in order to measure academic achievement and therefore their outcome measures have not undergone rigorous validation. One example of this is a study by Ramirez and Althouse (1995) where they developed and evaluated a project that employed ArcView software to help students examine several environmental issues. The teachers in the intervention received extensive training from the research team on the software and collaborated with the researchers to develop a two-semester curriculum that utilized its capabilities. The study then examined how the software was used in the curriculum and how it helped students develop an understanding of environmental sciences. In another study by McFarlane, Friedler, Warwick, and Chaplain (1995), the researchers used computer-based probes and graphing software to help seven and eight year old students to develop an understanding of how to build graphs. Once again, the research team worked closely with the teachers to help them use both the probes and the software. The final study then reported on the experience of using the technology in the classroom and gave pre- and post-test scores for students. As can be seen in both examples, the major weaknesses in these types of small-scale studies are that the classrooms studied often received a large amount of support that is not generally given to classrooms that would try to implement such an intervention at scale and that they represent very small sample sizes, which significantly limits their generalizability.

In order to examine the potential impact of technology-based interventions on learning, several research teams have conducted recent meta-analyses in order to determine the overall impact of technology-based interventions on a variety of outcomes. Early meta-analyses suggested that specific uses of technology generally demonstrated positive impacts on student achievement (Kulik, 1994; Goldberg, Russell, & Cook, 2003; Fletcher-Flinn & Gravat, 1995; Waxman, Lin, & Michko, 2003). However, several authors found the lack of quality in the early studies regarding the topic to be a serious problem. For instance, Waxman, Lin, and Michko (2003) found that of the 200 educational technology studies they found between 1997 and 2003, only 42 were able to meet their standards for inclusion. Of these, only 25% were categorized as randomized experimental designs, while another 67% were categorized as quasi-experimental designs. The authors also reported that what constituted "technology" and "student achievement" varied widely- possibly leading to confusion over what the outcomes truly represent.

More recent work has also been done in this area and several recent meta-analyses have also examined the impacts of teaching and of learning with technology on mathematics achievement (Li & Ma, 2010), reading achievement (Moran et al., 2008) as well as cognitive and affective outcomes (Lee et al., 2013). In Li and Ma's (2010) analysis of mathematics achievement, they found that the effect of technology on students' achievement was greater at the elementary than at the secondary levels and that the use of a constructivist approach was most highly related to achievement gains. Moran et al. (2008) found that the use of digital tools to enhance literacy acquisition in middle school students resulted in a significantly positive effect on reading comprehension. Lee et al's (2013) comprehensive meta-analysis of 58 studies found that cognitive outcomes were significantly improved when students collaborated in small groups or pairs and when technology was used for either basic skills, factual learning, or project-based learning. They concluded that for the affective domain, students had the greatest outcomes when teachers included challenging activities and engaged in instructional conversation and when students engaged in collaboration.

1.2 Research on 1:1 Initiatives

Presumably in response to both the positive learning outcomes demonstrated early on by researchers using specific technology-based interventions and the cultural recognition of the importance of technology in the workplace, many schools and school districts began implementing 1:1 computing programs that aimed to put one laptop in the hands of every child as a way to boost academic achievement. Research into the use and effectiveness of 1:1 initiatives continues to grow and has done a great deal in illuminating both how laptops are used in schools with 1:1 initiatives and the various outcomes associated with them.

Several studies began their investigations into the effects of 1:1 initiatives by examining how and how often computers were used in the schools in order to get a sense of how the amount of computer usage may affect learning. In a review conducted by Fleischer (2012), he found at least 4 studies where the authors reported the amount of usage. Across each study it was reported that students were using the computers almost every day for at least an hour per day. However, a study by Grimes and Warschauer (2008) found wide variability across schools in the extent to which the computers had been integrated in the curriculum. They reported that 36% of the teachers in one school reported using the computers for less than an hour per week compared to 78% of teachers at another school. There were also large differences across subjects in terms of how often the computers were used. For instance, the study by Grimes and Warschauer (2008) found that the computers were used the least frequently in mathematics whereas a study by Zucker and Hug (2008) reported greater use among math teachers- especially for doing daily drills with students. From this data, Fleischer (2012) concluded that there does not seem to be any individual topic better suited for laptop usage than another, but that usage will be dependent upon the creativity and the adoption of values and beliefs allowing for curriculum change that will largely determine the extent to which laptops will be used in the classrooms.

Fleischer's (2012) review also examined the ways in which laptops were reportedly used in the classroom. He found that the most frequent usage of the laptops seemed to be for exploration, expression, communication, and organization. In terms of exploration, several studies found that many schools used the computers to conduct online searches as well as engage with web-based computer simulations in order for students to grasp both surface- and deep-level concepts related to their area of inquiry (Grimes & Warschauer, 2008; Oliver and Corn, 2008; Zucker & Hug, 2008; Warschauer, 2007). Fleischer (2012) also found several studies that reported how the computers were used for student expression through the use of standard office applications as well as multimedia applications such as PowerPoint, iMovie, and Garageband (Dunleavy et al., 2007; Grimes and Warschauer, 2008; Oliver & Corn, 2008). Students were also able to use their laptops to engage in greater communication through email, discussion forums, and messenger applications and were able to use their laptops to organize their work (Dunleavy et al., 2007; Lei & Zhao, 2008). Overall, Fleischer (2012) found that the most common uses of laptops were to write and give presentations, complete information searches, and communicate electronically. In reporting on these uses, Fleischer (2012) comments that all of the studies showed either directly or indirectly that students in these initiatives had increased their technology-related skills through the daily use of computers in their classrooms.

In addition to examining how laptops are used within the context of 1:1 initiatives, the impacts of these programs on student outcomes have additionally been examined from several different angles, ranging from impacts on students' attitudes and interest in learning to impacts on academic achievement. In examining students' attitudes and interest in learning, several studies have indicated that students in 1:1 initiatives are more engaged and active in their learning. For example, a qualitative study by Storz, Hoffman, and Carroll (2013) found that teachers engaged in a 1:1 initiative reported increased engagement and motivation. A more quantitative study by Gulek and Demirtas (2005), they found that students who were given laptops spent more time engaged in collaborative and project-based instruction then students who did not have access to laptops. Silvernail and Lane (2004) also found that more than 70% of the students they surveyed reported that their laptops helped them to be better organized and get their work done faster and with better quality. In Silvernail and Gritter's (2007) report on Maine's 1:1 initiative, they found that 70% of students believed that the laptops facilitated their learning and that 80% reported that laptops increased their editing and self-correcting of their own work. Lowther et al. (2005) reported that over 60% of students in their sample stated that the use of their laptops increased their interest in learning and a large majority reported they were glad they were using laptops and wanted to use them again the following year. A study by Keengwe, Schnellert, and Mills (2012) found that 62.5% of students in their sample expressed that they were more motivated to do schoolwork when they used a laptop. Additionally, they found that 69% of the faculty surveyed reported improved student motivation and 77% reported improved engagement and interest level. In Alabama, the Auburn Laptop Initiative reported finding increased student engagement as well as an increase in inquiry-based learning (Intel Inc., 2008). Finally, another study in Massachusetts found that teachers overwhelmingly reported improvements in their students' engagement and motivation as a result of their 1:1 initiative with 83% of teachers feeling that engagement had improved for their traditional students, 84% reporting that engagement had improved for their at-risk/low achieving students, and 71% reporting that engagement had improved for their high achieving students (Bebell & Kay, 2010).

Several evaluations and studies of 1:1 laptop initiatives have additionally examined the impacts on students' academic achievement with the most common areas investigated being reading, writing, and mathematics. Although several studies have examined the impact of technology-based reading instruction on student achievement (see Moran et al., 2008), few studies have been able to systematically assess the relationship between student participation in a 1:1 initiative and reading achievement. However, the data gathered thus far indicates a possible positive trend. For instance, data collected by Gulek and Demirtas (2005) demonstrated positive gains in reading achievement for students in their laptop program with the caveat that these results varied based on the assessment given as well as the cohort of the students. Another study, conducted by Sclater et al. (2006) found that secondary students who participated in their laptop program had significantly higher scores on their standardized achievement tests and that these increased scores seemed to correlate with increased laptop use in the students' English classes. Once again, however, the authors warned that these results should be interpreted with caution, as there were several threats to the validity of their conclusions, including selection bias. In a study conducted by Bebell and Kay (2010), they found that although students in their laptop program did not score higher overall than students not participating in the program, cross-sectional analyses revealed a statistically significant (although fairly weak) correlational relationship between the amount of technology use in the classroom and students scores on their state English/Language Arts (ELA) assessment. Another study conducted by Shapley et al. (2010) found that student access and use of laptops was significantly and positively related to students reading achievement scores on Texas' standardized reading assessment for all 3 cohorts examined.

Overall, the information collected thus far on the impact of 1:1 laptop initiatives on reading achievement has been sparse and positive results have been weak. One possible reason for these results could be that reading is not as fundamentally impacted by the introduction of technology as other subjects/skills. The skills needed to read words on a screen are identical to the skills needed to read words in printed text. It is likely that 1:1 initiatives are likely to have impacts on reading only to the extent that schools/districts use the laptops to give students access to online, personalized curricula that directly improve their reading abilities, but that simply introducing the devices does not necessarily change reading instruction. As reading is critical within the educational setting, much more work needs to be conducted in order to gain a better sense of how 1:1 initiatives impact reading achievement across all grade levels.

Although few studies have examined the relationship between 1:1 initiatives and reading, much more work has been done on their impact on writing achievement. One reason for this is that the introduction of laptops (and therefore the use of word processing programs) often fundamentally shifts the writing process for students. As Holcomb (2009) notes, the introduction of laptop computers allowed students in her study to spend more time editing and reflecting on their writing rather than having students turn in their first, handwritten draft. A study conducted in Canada by Jeroski (2003) found extremely positive results when students and teachers were given 1:1 laptop access in addition to focused professional development aimed at improving students' writing abilities. They found that between their pre-test and post-test, the number of students who scored at the proficient level rose 22% (from 70% to 92%). Additionally, a study conducted by Lowther, Ross, and Morrison (2003) found a significant improvement in writing abilities for students who were provided access to laptops. In Maine, Silvernail and Gritter (2007) found that 5 years after implementation of the statewide 1:1 program, writing scores on the Maine Educational Assessment (MEA) was 3.44 points higher, indicating an effect size of .32. This means that the average students in 2005 scored better than approximately two-thirds of all students in 2000. In addition to this large difference in scores across time, Silvernail and Gritter (2007) also found a significant impact of computer use on students' writing achievement such that the effect size between students who reported not using their laptops during the writing process and those who used the laptops for all phases of the writing process was .64. This indicates that the average score for a student who used a laptop for writing was better than approximately 75% of those students who did not use the laptop for writing. Further analyses conducted by Silvernail and Gritter (2007) found that students' scores in writing improved regardless of whether the MEA was administered electronically or with paper and pencil, indicating that the laptops helped students become better writers in general and not just better when using their laptops. In addition to these reports, a study conducted by Zheng, Warschauer, and Farkas (2013) found significant writing test score gains in a California district implementing a 1:1 laptop program, while finding no significant increase in writing test score gains for a similar initiative in a Colorado district. However, they did note that across all districts, at-risk student groups did show significant gains and also used the laptops with greater frequency and for a wider variety of purposes.

Investigations of the impact of 1:1 initiatives on mathematics achievement have generally found smaller and more inconsistent effects than those found for writing. One significant explanation for this (as noted by Holcomb (2009)) is that evaluators consistently find that laptops were used the least frequently in mathematics classes. This was found to be true in Henrico County, Virginia, as well as in Maine and Michigan (Zucker & McGhee, 2005; Silvernail & Lane, 2004; Lowther et al., 2005). Despite this low level of use, Maine did experience an increase in student achievement in Math and students in South Carolina participating in a laptop program outscored non-participating students on the state standardized test for math (Muir, 2005; Stevenson, 1998). Evaluations of the Enhancing Missouri's Instructional Networked Teaching Strategies (eMINTS) program found that participating students significantly outscored their non-participating peers in both the 2002-2003 school year and again in the 2005 school year (eMINTS National Center, 2004; eMINTS National Center, 2007). A study conducted in Texas by Shapley et al. (2010) also found that students' access and use of computing devices had a significant, positive relationship with their state standardized math scores. In Bebell and Kay's (2010) study of students in Massachusetts, they found that student use of laptops in class was significantly related to students' scores on a state standardized test in math. Interestingly, they found that the overall level of student computer use in the classroom over the past year, students' computer use in Reading/ELA, and students' computer use in Science were all significantly, positively correlated with students' math scores, but that students' use of computers in math class was not. This may indicate that use of the computer in class aided students' math scores on a state standardized math assessment through a more indirect process than simply using them in math class to understand math concepts.

However, not all studies of mathematics achievement in 1:1 laptop initiatives have found positive results. A study conducted by Gulek and Demirtas (2005) did not find significant evidence of laptop students performing better on state standardized math assessments than their non-laptop peers. Another study conducted by O'Dwyer et al. (2008) in Massachusetts examining 4th grade students' scores on the state standardized math assessment did not find any significant impact of students' technology use on mathematics test scores. Taken together, these results suggest that while computers can be useful instructional tools for the teaching of mathematics, many districts implementing 1:1 initiatives are likely not providing their teachers with the types of support needed to enhance mathematics instruction through the use of laptop computers.

1.3 Technology-Supported Teaching Strategies

Many researchers and educational theorists have noted that technology has the potential to significantly change the way that teachers teach and students learn (Roschelle, Penuel, & Abramson, 2004; Storz, Hoffman, & Carroll year). There is no shortage of articles from various researchers and theorists that posit how shifts in pedagogical practice enabled by increased technology in the classroom could enhance the way students learn and engage with academic material. However, many of the proposed changes in teaching strategies associated with increased computer use tend to boil down to a few core practices that are made easier and/or more practical through the use of 1:1 computing: personalization of learning, creating authentic learning experiences, and computer-supported collaborative learning. For instance, in a qualitative study conducted by Storz, Hoffman, and Carroll (2013), they found that after teachers and students were given laptops as part of a 1:1 initiative, they reported increases in the extent to which teachers gave students options for various projects (personalization), gave more projects (collaboration), and allowed students to research topics they found interesting (authentic learning). While many would easily argue that none of these practices are earth-shattering or new, several researchers have pointed out how each has the potential to be enhanced through the use of increased computing technology. While there are several competing definitions of these strategies, the sections below highlight the definitions of these strategies as they were used for the current study.

Personalization of Learning. Patrick et al.'s (2013) working definition of personalized learning states "Personalized learning is tailoring learning for each student's strengths, needs and interests — including enabling student voice and choice in what, how, when and where they learn — to provide flexibility and supports to ensure mastery of the highest standards possible" (p. 4). The idea of personalizing students' educational experiences in order for them to receive the greatest benefit possible is not a particularly new idea, however it has been given renewed interest as technology has been able to make providing such individualized instruction more manageable and practical. Another name for personalized learning that has been widely used in the educational literature is "differentiated instruction". As explained by Hall (2002), the theoretical basis for differentiated instruction/personalized learning is grounded in the work of Lev Vygotsky (1978) and the concept of the zone of proximal development, where learning takes place. Research conducted since the 1980s has validated the effectiveness of many different types of teaching strategies consistent with differentiated instruction, including effective management procedures, grouping of students for instruction, and engaging learners (Ellis & Worthington, 1994 in Hall, 2002). Through the use of computer technology, teachers are better able to provide differentiated experiences for their students without as much preparation on the part of the teacher. For instance, students could choose different topics for an assignment and look up information on the web rather than having to rely on the teacher's or school's libraries. Teachers can also differentiate learning online by having students interact with online tools that tailor themselves based on the needs of the students. Several websites allow for students to practice skills such as addition and subtraction and will allow students to move on only once they have demonstrated proficiency in the current topic (usually through a test or quiz). In this way, students who are more proficient are able to move ahead and tackle more complex topics while students who still require more time to reach proficiency can take that time without the need for the teacher to provide additional worksheets. These types of sites are also beneficial in that each student can work at his/her own pace anonymously- thereby avoiding any social pressures or stigma that might come about when the teacher gives different levels of work to different students.

Authentic Learning. Much like personalized learning, authentic learning is a model of instruction that is not a new concept, has been called several different things over the years, and is emerging as a significant model through which to use modern computing technology to enhance classroom practice. The main idea behind authentic learning, sometimes also referred to as situated learning, stems from the realization that school knowledge, and academic concepts as they are taught in school, are often taught in a decontextualized fashion that can make it difficult for learners to know when and how to apply that knowledge to real-world situations (Herrington & Oliver, 2000). Herrington and Oliver (2000) give the example of a driver with a physics degree who attempts to dig his car out of the sand rather than partially deflating the tires- even though the driver has the knowledge necessary to solve the problem at hand, they are not able to recognize when that knowledge can/should be applied. Another common example within the realm of mathematics education is the famous study by Carraher, Carraher, and Schliemann (1985), which studied children engaged in commercial transactions on the streets of Brazil. They found that while the children were able to quickly and accurately calculate how much was owed to them for a given transaction and make change, these same children struggled significantly to apply the same mathematical concepts when given the exact same problems in a decontextualized manner (such as a paper and pencil test with both basic calculations and word problems). This research came about at a time when cognitive psychologists were beginning to emphasize the benefits of making connections between a person's knowledge and its use in real-world applications. By demonstrating that children were able to solve problems without knowing or using traditional computational routines, the study challenged educators' traditional forms of pedagogy which held that students must be taught how to do the calculations involved in a problem before they could be handed the problem itself (Clements, 2004).

This type of research led researchers such as Resnick (1987) and Collins (1988) to put forth a call for situated learning models of instruction. Resnick (1987) proposed that "bridging apprenticeships" be designed to help bridge the gap between theoretical learning and the real-life application of that knowledge. While such apprenticeships are useful tools, they can also be extremely difficult to manage and provide to all students. In order to develop a more concrete model of instruction that could be used across all classrooms, Collins (1988) created a model of instruction that focused on situated learning in the classroom. He defined situated learning as "the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life" (p. 2). While there has been debate among theorists regarding whether or not the use of computing technologies to provide authentic learning experiences, through computer-based simulations or similar technologies, provides the same cognitive and academic benefits as a more traditional apprenticeship approach, there is increasing agreement that computer-based representations provide a powerful vehicle for the critical characteristics of situated learning within the classroom environment (Herrington & Oliver, 2000). Herrington and Oliver (2000) comment that many of those involved with situated learning models have accepted that a computer can provide an alternative to the real-life setting without sacrificing the authenticity of context that is a crucial element of the model. Because of the lower costs of using computer technology to provide for authentic learning experiences, many districts and schools are attempting to use technology as a substitute for more traditional apprenticeship-type approaches. For more concrete examples of how to use the principles of authentic learning in practice, see Herrington and Kervin's (2007) "Authentic Learning Supported by Technology: Ten suggestions and cases of integration in classrooms".

Computer-Supported Collaborative Learning. Computer-supported collaborative learning (CSCL) has developed into an emerging field of inquiry in its own right in recent years. While the idea of having students collaborate and learn together in small groups is (like the other concepts discussed above) not a wholly new concept, it has gained increased attention due to the possibilities of computer technology. Indeed, the study of cooperative learning has been around since at least the 1960s and research on group processes has an even longer history within the social sciences (Stahl, Koschmann, & Suthers, 2006). However, as computer technology has become more advanced and available in recent years, many researchers in education have begun focusing on how computers can be used within a collaborative group environment in order to improve the learning process. As explained by Koschmann and Suthers (2006), CSCL developed in the 1990s partially as a reaction to the development of software that was designed to individualize student learning in a socially isolated setting. Rather than taking the view that learning is best accomplished through an isolated, individualized experience, various researchers and educators focused on the potential for computer technology to connect individuals in order to foster a more social learning experience. They reason that through the appropriate use of CSCL, students become more engaged with the material and therefore demonstrate better learning outcomes.

When defining collaborative learning, many researchers draw a distinction between *cooperative* and *collaborative* learning. As Dillenbourg (1999) states "In cooperation, partners split the work, solve sub-tasks individually and then assemble the partial results into the final output. In collaboration, partners do the work 'together.'" (p. 8). CSCL is thus defined as a process through which several individuals collectively utilize technological tools to engage in the learning process in order to create knowledge and/or products that are a result of their collective effort. While there are many studies that have attempted to elaborate on the best ways to engage in online collaboration, few, if any, studies have attempted to examine the direct impact of engaging in collaborative learning on individual learning outcomes (Brett, 2004). Some researchers within the CSCL community argue that because of the inherent social interconnectedness that is created through group collaboration, the measurement of individual impacts would be inappropriate and that analyses should instead focus on a group level of analysis (Stahl, 2004). However, others argue that individual impacts should be measured through their engagement in group construction of knowledge- that through peer group collaboration, individual students learn how to construct meaning in more complex ways than they would be able to do alone (Blumenfeld et al., 1996).

The evidence so far indicates that collaborative learning approaches are positively related to a number of student outcomes including academic achievement, development of higher order thinking skills, and satisfaction (Resta & Laferrière, 2007). Studies examining the use of computers in cooperative, competitive, and individualistic learning found that CSCL leads to higher quantity and quality of daily achievement, greater mastery of factual information, and greater success in problem solving when compared to computer-supported individualistic learning (Johnson & Johnson, 1989; Johnson et al., 1998; Johnson, et al., 1990; Johnson et al., 1987; Resta & Laferrière, 2007). Researchers have also found that when compared to face-to-face groups, online groups engaged in more complex and cognitively challenging discussions (Benbunan-Fich, Hiltz, & Turoff, 2003). Students who have greater peer interaction, whether face-to-face or online, have also been found to have more positive attitudes towards the subject matter, are more satisfied with their experience, and have an increased motivation to learn (Johnson et al., 1998; Springer, Stanne, & Donovan, 1998). Additionally, research has also found that online groups are able to deliver more complete reports, make higher-quality decisions, and perform better on tasks that require them to generate ideas when compared to face-to-face groups (Benbunan-Fich, Hiltz, & Turoff, 2003; Fjermestad, 2004). Taken together, this evidence supports the idea that CSCL has the possibility to significantly improve student outcomes.

1.4 Student Engagement

While many studies have focused exclusively on the impact of 1:1 initiatives on academic achievement, a large number have also investigated how the use of computers may impact student academic engagement. This is due to the recognition by researchers that while the increased use of technologies may have a limited direct impact on academic achievement, the use of new technologies may have the potential to positively impact student engagement, which could lead to a number of positive outcomes down the road, such as increased interest in a particular topic and an increased desire to continue their education post-high school. As demonstrated earlier, researchers have consistently found a significant relationship between 1:1 initiatives and increased student engagement, however one limitation of these findings is that the operational definitions of student engagement varied considerably between studies. For the purposes of the current study, the construct of School Satisfaction will be used as the indicator of student engagement. Grounded in the theoretical literature surrounding subjective well-being (SWB: Diener, 1984), school satisfaction is an important indicator of well-being in school-aged children. School satisfaction has been defined as a student's evaluation of his or her school experience "as a whole" (Huebner, 1994), meaning that it is a cognitive construct that is based on the students' own subjective evaluation of his/her own experience. Previous studies have supported the contention that school satisfaction is a distinct domain of students' general life satisfaction among adolescents (Huebner et al., 1998; Seligson et al., 2003). Importantly for the present study, previous research has found that students often report significantly lower levels of school satisfaction compared to their satisfaction with other domains in their life- meaning that this is an area of well-being that has significant room for improvement (Huebner et al., 2005).

Research on school satisfaction has consistently provided evidence of its importance as well as its ability to predict a host of both positive and negative outcomes. Among adolescents, low levels of school satisfaction have been linked to poor school achievement (Baker, 1998; Ladd, Buhs, & Seid, 2000) and internalizing and externalizing behavior problems (DeSantis-King et al., 2006; Huebner and Gilman, 2006), including depression (Eamon, 2002), suicidal ideation (Eamon, 2002; Locke and Newcomb, 2004), and substance use (Newcomb et al., 1987; Oakley et al., 1992; Strivastava and Strivastava, 1986). Thus, this evidence joins a large and continuously growing body of literature demonstrating the severe long-term impacts of poor schooling experiences. If students do not feel engaged in their school or are not satisfied by their schooling experience, this data suggests that they are significantly more likely to engage in negative behaviors and have several negative outcomes. On the opposite side, high levels of school satisfaction have been demonstrated to relate to several positive academic and behavioral outcomes such as engaged classroom behavior (Elmore and Huebner, 2010), higher motivation towards learning (Keys and Fernandes, 1993), commitment to school (Goodenow and Grady, 1992; Wehlage et al., 1989), and school completion (Ekstrom et al., 1986; Okun et al., 1986).

In addition to researching the outcomes associated with students' levels of school satisfaction, various studies have also examined the various correlates of school satisfaction. Many of these studies have examined both classroom- and school-level factors in an attempt to illuminate the most important sources of school satisfaction for students. For instance, studies by Epstein (1981) and Baker et al. (2003) found that supportive teacher behavior was a significant correlate of students' school satisfaction. Futher studies of teacher behavior by Furrer and Skinner (2003) found that both teacher-imposed classroom climate (Furrer and Skinner, 2003) and the provision of meaningful, appropriately challenging instructional tasks were also significant correlates of students' school satisfaction (Maton, 1990; Wong and Csikzentmihaly, 1991). Another study by Jiang, Huebner, and Siddall (2012) found that teacher-related social support significantly predicted students' school satisfaction in both cross-sectional and longitudinal analyses. Taken together, this data indicates that teachers' levels of social support and their provision of engaging instructional tasks both significantly relate to students' school satisfaction. Thus, if schools can effectively increase both teachers' provision of social support as well as appropriate, engaging instructional tasks, they can likely significantly impact students' school satisfaction as well as their more distal developmental outcomes. This would imply that one way that the use of computing technology may impact students' school satisfaction would be through the provision of more effective instructional practices.

1.5 21st Century Learning Skills

It has been largely accepted that the world economy (and especially the economy in the United States) is moving towards an information or knowledge society. As information becomes more easily available and as jobs requiring repetitive tasks (such as factory work) become increasingly scarce due to the development of robotic technologies, many theorists have extolled the need for more workers who will be able to perform in-person services (such as childcare workers) and those who will be able to identify, analyze, and solve novel problems in a complex world. As Levy and Mundane (2004) argued, tasks that are rule-based will become increasingly automated through computers, but jobs that require the ability to understand and interpret complex patterns will become increasingly important. They note that as computer technologies have advanced, the need for jobs that acquire information will be diminished and the particular understanding of new information will be paramount in many jobs and professions. In response to the ever-changing needs of the 21st century workforce, many in both the business and education realm have called for the development of new competences, often referred to as 21st Century Skills.

Those who argue for the development of 21st century skills in todays workforce note that one of the major challenges facing society is that students are increasingly having to study for jobs that do not yet exist (Fisch & McLeod, 2009; Voogt & Odenthal, 1997). They discuss how many of the jobs people hold today were not around even 10 or 15 years ago and wonder how we are going to train students for the jobs of the future when those jobs will often be taking shape after the students have already completed their formal education. In their view, the main purpose of education is to prepare students for participation in the workforce and they increasingly see a disconnect between the way students are taught in traditional classrooms and the type of work they will be asked to conduct once they are in the workforce. For example, Collins and Halverson (2009), in their book *Rethinking Education in the Age of Technology*, argue that because the barriers of accessing information have significantly dissolved thanks to the rise of the internet and other communication technologies, education no longer needs to exclusively happen within the context of formal schooling. Indeed, they hypothesize that if schools do not keep up with the demands of teaching 21st century learners, that individuals will begin to seek their education outside of the school context. Already they note that the main impact of technology on education has occurred largely outside the school setting. Interestingly, in order to tackle the seemingly intractable problem of how to incorporate rapidly-changing technologies to educate students for jobs that do not exist yet, many theorists have taken a similar approach as the proponents of the liberal arts and argue that although the tasks these jobs will require may vary substantially, at the core of all of them are a basic set of competencies that individuals need to have- what they refer to as 21st Century Skills.

*Defining 21st Century Skills***.** Although many authors have argued for their necessity, there is no single, universal framework currently accepted as the definitive set of skills necessary for success in the 21st century workforce. In a review of 21st century skills frameworks by Voogt and Roblin (2010), they identified 5 different frameworks that seemed to have considerable support behind them: Partnership for 21st century skills (P21), EnGauge, Assessment and Teaching of 21st Century Skills (ATCS), National Educational Technology Standards (NETS), and Technological Literacy Framework for the 2012 National Assessment of Educational Progress (NAEP). They were also able to identify studies on 21st century skills conducted by researchers affiliated with the European Union (EU), the Organization for Economic Cooperation and Development (OECD), and the United Nations Educational, Scientific, and Cultural Organization (UNESCO). In addition to demonstrating the complexity involved in distilling down what skills are included as 21st century skills, the large number of organizations and their national and international significance attest to the priority 21st century skills are being given not just in the United States, but around the world as well. In their review, Voogt and Roblin (2010) were able to summarize the types of skills found most commonly across the various frameworks. They found that the skills of collaboration, communication, Information and communication technology (ICT) literacy, social and/or cultural skills, including citizenship, were mentioned in *all* of the frameworks they found. In addition, they found that *most* of the frameworks also included creativity, critical thinking, problem solving, and developing quality products/productivity. Of note, only the EU, P21, and ATCS frameworks included any mention of traditional core academic subjects, an indicator of how many of these frameworks postulate that these skills should be used in a cross-discipline fashion and as a complement to- not a replacement for- traditional academic subjects.

Because of the importance of 21st century skills for students' future careers, one may argue that students obtaining these skills could be just as important, if not more important, than their ability to score well in academic domains. Proponents for 21st century skills correctly point out that the nature of information is changing at a much faster rate than in previous decades. According to an analysis by Hilbert (2012), the amount of information that we are able to store digitally has roughly doubled every 3 years since 1986 and by 1997 roughly 97% of the information stored in the world was stored in a digital format. This means that facts are both rapidly changing as science continues to progress at an exponential rate, and that it is now more readily available to the average person than ever before. What this means for education and learning remains to be seen, but many argue that the skills of being able to retrieve, organize, analyze, and explain information are becoming much more important than relying on memory of learned facts. For this reason, as well as many others, 21st century skills may represent a domain of functioning separate from traditional academic outcomes, but nonetheless equally critical to an individual's success in the workforce post-graduation.

Not only are 21st century skills likely to be extremely important to students in the future, but they may also serve as a better means through which to understand the impacts of the technological initiatives being rolled out in many states, districts, and schools across the country (as described above). Indeed, a handful of researchers have argued that the use of state-required standardized test scores in traditional academic subjects may not provide valid measures of the types of learning that occurs through the use of technology despite their increased use in measuring the outcomes of technology initiatives (O'Dwyer et al., 2008). For instance, Russell (2002) has argued that state-required standardized tests attempt to measure broad academic domains and that they therefore are prone to miss the specific skills that may be taught specifically through the use of technology. He also argues that the use of paper-based tests may be significantly underestimating the impact of technology use due to students being unable to use the technology while being tested. Russell and his colleagues even provide convincing evidence that students who are accustomed to writing with computers perform between 0.4 and 1.1 standard deviations higher when they are allowed to use computers while being tested (Russell, 1999; Russell & Haney, 1997; Russell & Plati, 2001). Because of these significant weaknesses in using state-required standardized tests to measure the outcomes associated with technology initiatives, it is likely that examining the impact of technology initiatives on students' 21st century skills may be both a more accurate and worthwhile avenue of inquiry.

Measuring 21st Century Skills. Despite several authors' attempts to demonstrate what 21st century skills look like when used in the academic setting, a way to systematically examine the presence of these skills in a large-scale, standardized manner has remained elusive. One reason for this is that many of the aforementioned frameworks focus on assessment at the individual teacher level rather than at a group level (Voogt & Roblin, 2010) and therefore have not yet turned their attention to developing assessments that could compare groups of students without going through the burdensome process of portfolio evaluations. Another difficulty is that even though the skills are detailed within all of the various frameworks, few, if any, of the frameworks have identified a framework for technology integration that helps teachers understand the various levels of use or help them understand the level of knowledge students need at each particular grade level. However, there are a very small handful of resources out there developed by state departments of education and university centers to help teachers and administrators with this issue. For instance, the Florida Center for Instructional Technology at the University of Florida created a Technology Integration Matrix to help teachers and administrators understand the various levels of use for what they have described as "characteristics of meaningful learning environments" (Technology Integration Matrix, 2011) and even provide several tools for examining technology integration in schools using their framework. The Georgia Department of Education also created an extremely useful resource when they created a full K-8 scope and sequence based on all of the ISTE NETS-S standards (GeorgiaNETS, 2011) that details what skills students are expected to master at each grade level. While both of these resources could be incredibly useful for schools and districts interested in implementing and evaluating their technology initiatives, both fail to provide a concrete way to measure the level of 21st century skills in their students in a way that can be compared to students in other schools and states.

One assessment that does enable schools to measure 21st century skills is the 21st Century Skills Assessment (21CSA) created by Learning.com. The 21CSA was developed in such a way as to both measure students' 21st century skills and to do so in a way that takes advantage of the possibilities in using technology for assessment purposes. For instance, while some of the questions on the assessment are simple multiple choice answers, several of the questions (especially questions about how to use technology tools) utilize simulated applications to test students' actual knowledge of how to carry out specific tool-related processes such as copying and pasting and inserting objects into a word processing program. The 21CSA was also matched to ISTE's NETS-S standards and provides both independent scores for each of the 6 standards as well as an overall performance score. The NETS-S standards are detailed below (ISTE, 2014):

1. Creativity and Innovation
   Overall: Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.
   a. Apply existing knowledge to generate new ideas, products or processes.
   b. Create original works as a means of personal or group expression.
   c. Use models and simulations to explore complex systems and issues.
   d. Identify trends and forecast possibilities.
2. Communication and Collaboration
   Overall: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
   a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.

b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
d. Contribute to project teams to produce original works or solve problems.

3. Research and Information Fluency
   Overall: Students apply digital tools to gather, evaluate, and use information.
   a. Plan strategies to guide inquiry.
   b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
   c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
   d. Process data and report results.
4. Critical Thinking, Problem Solving, and Decision Making
   Overall: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
   a. Identify and define authentic problems and significant questions for investigation.
   b. Plan and manage activities to develop a solution or complete a project.
   c. Collect and Analyze data to identify solutions and/or make informed decisions.
   d. Use multiple processes and diverse perspectives to explore alternative solutions.
5. Digital Citizenship
   Overall: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.
   a. Advocate and practice safe, legal, and responsible use of information and technology.
   b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
   c. Demonstrate personal responsibility for lifelong learning.
   d. Exhibit leadership for digital citizenship.
6. Technology Operations and Concepts
   Overall: Students demonstrate a sound understanding of technology concepts, systems, and operations.
   a. Understand and use technology systems.
   b. Select and use applications effectively and productively.
   c. Troubleshoot systems and applications.
   d. Transfer current knowledge to learning of new technologies.

Because of the 21CSA's ability to measure students' 21st century skills, this framework and assessment will be used as a measure of students' 21st century skills. By using this framework and assessment, this study will be able to examine the impact of technology use in the classroom on students' 21CSA scores and therefore provide a more nuanced and informed view of how a 1:1 technology initiative impacts students' learning.

1.6 Studies on 1:1 Initiatives

As has been documented above, there has been a significant amount of research on the potential of 1:1 initiatives to impact academic achievement and engagement as well as technology-related teaching strategies and students' school satisfaction and relatively little work done on 21st Century Skills. However, none of the research to date has made an attempt to examine the relationships between these teaching strategies and student outcomes. The most notable exceptions are studies by O'Dwyer et al. (2005), O'Dwyer et al. (2008), and Shapley et al. (2010), which primarily examined how computer use related to various academic outcomes.

In O'Dwyer et al.'s (2005) study, the researchers examined the relationship between both home and school computer use and students' English/Language Arts state standardized test scores. They collected data from 986 fourth grade students across 55 classrooms in 9 school districts across Massachusetts via both teacher and student surveys and state-required standardized test scores as part of the Use, Support, and Effect of Instructional Technology (USEIT) study. The USEIT study was conducted across 3 years and aimed to investigate both how technology was being used by teachers and students as well as how this technology use affected student learning outcomes. In

O'Dwyer et al.'s (2005) study, they examined 5 teacher uses of technology, including "Teachers use of technology for delivering instruction", "teacher-directed use of technology during classtime", "Teacher-directed student use of technology to create products", "Teachers' use of technology for class preparation", and Teachers' use of technology for student accommodation". They also investigated 3 student uses of technology, including "Student use of technology at school", "Student recreational use of technology at home", and "Student academic use of technology at home". O'Dwyer and colleagues (2005) adopted a multi-level analytic approach in order to examine student-level indicators nested inside teacher-level indicators. They found that student reports of how often they use a computer in school to edit papers and recreational home use consistently predicted students' overall ELA scores, writing scores, and reading and literature scores in their models. Interestingly, while the use of technology to edit papers was associated with higher student scores, home recreational use was associated with lower student test scores. Another interesting finding noted by the researchers was that the use of computers during the writing process was found to have a positive relationship with students' performance on the essay section of the state-required standardized test, despite the test requiring the students to use a paper and pencil. This study was one of the first to provide a more nuanced look at the relationship between computer use and student achievement through both the measurement of specific types of technology use as well as their use of a multi-level analytic approach that was better able to examine how the student-level and teacher-level indicators impacted academic achievement differently.

In a follow-up study, O'Dwyer et al. (2008) examined the impact of technology use at home and school on 4th grade students' state mathematics test scores. Once again, the researchers examined data from 986 students in 55 classrooms across 25 schools in 9 districts in Massachusetts as part of the USEIT study. They examined the same teacher-level and student-level predictors and once again utilized a multi-level analytic approach. Unlike in their previous analyses where they found a positive relationship between technology use at school and ELA scores, O'Dwyer and colleagues (2008) were unable to find any significant predictors other than students' previous test scores and a measure of their socioeconomic status. They even found that their measure of general technology use had a significant negative relationship with students' scores on the Geometry subsection of the test. One hypothesis put forth by the researchers as to their lack of findings was that despite the fact that one third of the classrooms in their study were considered "high-use" classrooms, when they examined the students' responses about computer use specifically in their math classes, few students reported using their computers for math more than once per month. Thus, the potential for computer usage to impact students' scores was likely negligible.

Arguably one of the most comprehensive studies of how a technology immersion initiative impacted student achievement outcomes is Shapley et al.'s (2010) pilot study of the Technology Immersion model implemented in Texas starting in 2004. Shapley and colleagues studied 21 Technology Immersion middle schools and examined how they implemented the Technology Immersion model and how implementation affected student outcomes. They posited that as schools are provided increased technological resources, they will produce teachers who are more technologically proficient and use technological resources to increase the intellectual rigor of lessons which will lead to changed school and classroom conditions that will further lead to improved student technological literacy, engagement, and learning. In their introduction, Shapley et al. (2010) make a strong argument for the need to measure the extent of implementation when evaluating the effectiveness of 1:1 laptop initiatives. The researchers gathered data from Fall 2004 until Spring 2008 and decided to divide up the students into 3 cohorts: Cohort 1 (8^{th} graders in 2006-07 who attended Technology Immersion schools for the first 3 project years), Cohort 2 (8^{th} graders in 2007-08 who attended Technology Immersion schools for 3 years), and Cohort 3 (7^{th} graders in 2007-08 who attended Technology Immersion schools for only 2 years). They had approximately 2,500 students in each cohort with a large majority of the students coming from an economically disadvantaged background (approximately 75%). The researchers included 3 core areas of implementation (Support for Technology Immersion, Classroom Immersion, and Student Access and Use) in their analyses. Of most interest to the current study, the Classroom Immersion components that were reported by the teachers consisted of 1) Technology Integration, 2) Learner-Centered Instruction, 3) Student Classroom Activities, 4) Communication, and 5) Professional Productivity. The Student Access and Use component (which was reported by the students) consisted of 1) Laptop Access, 2) Core-Subject Learning, and 3) Home Learning. The researchers then utilized a two-level hierarchical linear model (with students nested within their reading and mathematics teachers) to examine the impact of these various factors on students' state reading and mathematics scores. Their analyses revealed that their teacher-level implementation components were inconsistent and were mostly not statistically significant predictors of academic achievement whereas students' use of laptops outside of school for homework and learning games was the strongest predictor of achievement. One way these findings are particularly interesting is how they relate to O'Dwyer et al.'s (2005) findings regarding student home use of computers. While Shapley et al. (2010) found that home use of computers to do homework was significantly related to higher academic scores, O'Dwyer et al. (2005) found that home use of computers for recreational purposes was negatively related to students' test scores. This may call into question whether or not the actual use of technology is responsible for the effect, or whether these two items distinguish between two types of students- one group that uses their technology at home for recreation and not school and another that uses their technology at home for school rather than recreationally. One could imagine that there are likely underlying personality factors that could be driving both the way they use their technology at home as well as their overall academic performance.

1.7 The Current Study

The current study aims to add to the growing body of knowledge surrounding 1:1 implementation by examining how the specific technology-supported teaching strategies (Personalized learning, Authentic learning, and CSCL) potentially influence students' school engagement, academic outcomes, and 21st century skills. While there are several studies that have examined the general impact of technology on student outcomes, few have sought out and investigated the specific, classroom-level mechanisms through which changes in student outcomes occur. As elucidated above, most studies examining the impact of 1:1 technology initiatives have focused on simply examining whether or not students participating in a 1:1 initiative outperform similar students who are not participating. The three studies mentioned in the previous section are the only known, published studies that attempt to dig deeper and examine how the provision of technology impacts student performance through the study of specific activities engaged in by students and teachers. Even among these studies, only the study by Shapely et al. (2010) investigated these mechanisms within a specific 1:1 initiative.

The present analysis will be broken down into two parts: Impacts on Academic Outcomes and Impacts on 21st Century Skills. These will be described in more detail below

Study 1: Impacts on Engagement and Academic Outcomes. The first part of the study will focus on the impact of technology-supported teaching strategies on student engagement as well as traditional measures of academic achievement. As documented above, student engagement is often seen as a significant impact of 1:1 technology initiatives and is commonly used to investigate the impacts of these initiatives on students. As 1:1 technology initiatives seek to improve the learning environment in schools, student engagement is often seen as one of the best ways to measure such impacts.

However, administrators and those funding such expansive initiatives often wish to examine impacts beyond students' engagement. Despite the significant weaknesses in using state-required standardized test scores cited above, they continue to be the gold standard upon which many initiatives are judged. When schools, districts, and states invest millions of dollars into large-scale technology initiatives, one of the things they want to know is whether or not it will have any type of significant impact on student academic achievement. Despite the numerous theoretical and methodological issues with this approach, students' academic test scores significantly impact how schools are funded under the No Child Left Behind Act (NCLB, 2001). While state- and district-level administrators are able to not make raising state-required standardized test scores a proposed outcome of their technology initiatives, it is still beneficial for them to know whether or not this type of an intervention will result in such an outcome. If raising test scores is the sole focus for an administrator, it would be useful for them to know whether or not they would be better served putting money behind a technology initiative or whether that money may achieve their goal faster through ideas such as raising teacher salaries to attract new teachers or for the provision of additional support personnel. Based on the current state of the literature, the current researchers propose the following questions to be answered in this study:

1. Do the technology-supported teaching strategies of Personalized, Authentic, and Collaborative Learning and Technology Integration impact students' school satisfaction?
2. Do the technology-supported teaching strategies of Personalized, Authentic, and Collaborative Learning and Technology Integration impact students' academic achievement in reading and/or mathematics?

In addition to these questions, the current study examines the impact of school-wide levels of technology-supported teaching strategies on students' achievement in reading and mathematics as well as students' school satisfaction. As demonstrated in the study by Grimes and Warschauer (2008), there is often variability in how different schools implement their 1:1 technology initiatives. Thus it is a distinct possibility that students' outcomes could vary by school and that these variations may be accounted for by the extent to which whole schools engage in these teaching strategies. As teaching is a profession that often involves collaboration among teachers within schools, it is hypothesized that school-wide levels of technology-supported teaching strategies may have impacts above and beyond the impacts students report for their individual teachers. In order to investigate this question thoroughly, school-wide levels of teachers' technology-supported teaching strategies were obtained both through student and teacher reports.

Additionally, since each school may have implemented the 1:1 initiative differently, and thus have varied outcomes associated with implementation, the current study examines the extent to which factors associated with school-wide implementation may impact students' outcomes above and beyond the teaching strategies of individual teachers. In order to investigate this possibility, a measure of implementation practices was created based on the Quality Implementation Tool (QIT) created by Meyers et al. (2012) and used to examine students' outcomes by implementation practices.

Study 2: Impacts on 21st Century. As described above, a more appropriate outcome to study in relation to technology initiatives may be the development of 21st century skills. Many districts that have implemented 1:1 technology initiatives have stated that they hope to accomplish much more than simply raising student test scores- that they aim to increase students' technological proficiency in order to prepare them for their roles in the workforce. By focusing on 21st century skills as a potential outcome, districts will be able to more closely align their teaching objectives to these outcomes in a cross-disciplinary fashion that will provide students with a more in-depth and relevant educational experience that is likely to not only engage them in the lesson at hand, but enable them to be lifelong learners once they leave the formal classroom setting.

Therefore, this study will seek to answer the following questions in order to examine how technology-related teaching strategies potentially impact students' 21st century skills:

1. How do the technology-supported teaching strategies of Personalized, Authentic, and Collaborative Learning and Technology Integration impact students' overall scores on the Learning.com 21CSA assessment?
2. How do the technology-supported teaching strategies of Personalized, Authentic, and Collaborative Learning and Technology Integration impact each of the six 21st century skills standards proposed by ISTE's NETS-S standards?

This analysis will be especially important in light of the extreme dearth of research on how 21st century skills can be developed. Although there are a plethora of 21st century skills frameworks and articles that defend their utility, we were not able to find a single published article using 21st century skills as a measurable outcome. By demonstrating the impacts of technology-supported teaching strategies on students' 21st century skills outcomes, the current study will be able to provide evidence for ways in which these skills can be enhanced in the school setting.

CHAPTER 2

METHODS

Data for this study was collected by the Richland 2 school district and shared with the Getting To Outcomes® (GTO) team as part of their evaluation of the Richland 2 1 TWO 1 Computing initiative. Data for this study was collected through three different data sources during spring 2014: student survey data, district testing data, and data from the Learning.com 21st Century Skills Assessment. The details of each data collection method will be described below.

2.1 Data Collection

Survey Data.

Every school in the Richland 2 School District was encouraged to have their students and teachers take a survey regarding their use of technology, teaching practices relating to the use of technology, as well as a number of other domains such as school satisfaction and engagement. The GTO team collaborated with the district staff in order to develop a survey administration plan that included the Director of Assessment and Accountability emailing each principal and asking them to send the survey link to their teachers and to have it completed by the end of the school year. In order to incentivize schools to complete the survey, a technology gift basket was offered as a reward to whichever school had the highest completion rates. The survey opened on April 28th, 2014 for elementary, middle, and high schools and the last survey was completed on June 2nd, 2014. During that time, 13,256 students and 1,570 teachers completed at least one part of the surveys. After the data was cleaned to avoid duplicates, high school students, and additional students that lacked sufficient data for the study the total dataset included 8,047 students and 517 teachers in grades 3-8. High school students were not examined for the current study due to a low level of representation across high schools. The student dataset was 49.2% male and 50.8% female. The majority of the student sample consisted of students who identified as Black/African American (55.3%) with 29.8% of the sample identifying as White, 6.6% Spanish/Hispanic/Latino, .1% Native American, 3.8% Asian or Pacific Islander, and 4.4% identifying as Other. Sample demographics are consistent with the overall demographic statistics reported by the district for the 2013-2014 school year. The number of students for each grade ranged from 1166 in grade 3 to 1548 in grade 6. Of those in the sample, 47.1% qualified for free/reduced price lunch and 6.4% of the sample were students in special education. State records indicated that sample demographics were within 4% of state-reported demographics in all areas except for special education status, with only 6.4% of the sample receiving special education services compared to 11.5% of students in the district (South Carolina Department of Education, 2016). Student demographic data can be found in Table 1.

Measures Included in Survey. *Multidimensional Students' Life Satisfaction Scale (MSLSS; Huebner, 1994).* The MSLSS is a 40-item self-report measure of students' satisfaction in 5 domains relevant to their lives: Family, Friends, School, Living Environment, and Self. Students respond on a seven-point Likert scale ranging from 1= *Strongly Disagree* to 7= *Strongly Agree*. Higher scores on the scale represented higher levels of satisfaction. The MSLSS has been used successfully with children between the ages of 8-18 (Gilman, Huebner, Laughlin, 1999; Huebner, 1994; Huebner et al., 1998).

Table 2.1. Sample Demographic Statistics.

	Percentage of Sample	District Demographics
Sex		
Male	49.2%	50.9%
Female	50.8%	49.1%
Race		
White	29.8%	26.1%
Non-White	70.2%	73.6%
SES		
Paid Lunch	52.9%	54.7%
Free/Reduced Lunch	47.1%	45.3%
Special-Education		
Not in Special Ed.	93.6%	88.5%
In Special Ed.	6.4%	11.5%

For the purposes of this study, the School Satisfaction subscale of the MSLSS was used as the measure of students' school satisfaction. This subscale consists of eight questions designed to measure the extent to which each student is satisfied with their overall experiences in school (e.g.. "I like being in school"). Previous research has supported the reliability of the 8-item measure (alpha = .79) with school-age children and adolescents (Baker, 1999). The reliability in the current study was consistent with previous estimate (alpha = .82). Concurrent validity has been suggested by a positive relationship (r = .68) with the Quality of School Life Scale (Epstein & McPartland, 1976) in a sample of preadolescent students (Huebner, 1994).

Student Report of Teachers' Use of Personalized, Authentic, and Collaborative Learning Strategies and Tech Integration. In order to measure teachers' use of Personalized, Authentic, and collaborative learning strategies, scales had to be developed by the author of this study. This was due to a lack of valid or reliable scales in the literature that could adequately address these domains within a survey response format. The questions were specifically designed to measure the constructs of Personalized, Authentic, and Collaborative learning as they were being implemented by district personnel in Richland School District 2. The questions were analyzed both by the GTO team and Richland 2 district staff in order to check both their face validity and their acceptability. Each question was asked about both the students' Math and English/Language Arts (ELA) teachers. The questions used for each scale are below ("Subject" was replaced by ELA and Math in the final versions):

Personalized (Responses: 1- “Strongly Disagree” to 5- “Strongly Agree)

1. My (Subject) teacher knows how I learn best and teaches me that way
2. My (Subject) teacher lets me choose how to do my assignments

Authentic (Responses: 1- “Strongly Disagree” to 5- “Strongly Agree)

1. My (Subject) teacher shows me how the things we learn in class relate to other parts of my life.
2. My (Subject) teacher gives me work that deals with things that happen in real life.
3. My (Subject) teacher shows me how what I learn in class is useful for my life outside of school

Collaborative (Responses: 1- “Never”, 2- “Rarely”, 3-“Sometimes”, 4- “Often”, 5- “Always”)

1. We work in small groups online either inside or outside the classroom.
2. We work together in groups to complete a project that takes more than one week to finish.
3. We work together to create documents (e.g. google presentations, docs, etc.)
4. I send messages or chat with someone outside of my classroom (e.g. on Google Hangout, Google Docs, Email, Google Chat, etc.)

The Cronbach’s alpha for each scale in the sample is approximately .75 for ELA Personalized, .903 for ELA Authentic, .845 for ELA Collaborative, .800 for Math Personalized, .918 for Math Authentic, and .886 for Math Collaborative.

Technology Integration was obtained by asking the students “Please tell us how often you use your computing device to do work in... (English/Math)” with the response options being “Not at all”, “1-2 days/week”, “3-4 days/week”, “Every day”, and “N/A”. Several other evaluations of 1:1 technology initiatives have used this type of question to measure the level of technology integration in schools and classrooms (Shapley et al., 2010; O’Dwyer et al., 2008).

Teachers’ Report of Use of Personalized, Authentic, and Collaborative Learning Strategies and Tech Integration. In order to measure teachers’ use of personalized, authentic, and collaborative learning strategies, teachers were asked to rate how often they engaged in technology-supported teaching strategies. Each of the questions was designed to reflect the ISTE NETS-T teaching standards (Voogt & Roblin, 2010). Questions and teachers’ response options are listed below:

Personalized Learning. (Responses: “Never”, “Rarely”, “Sometimes”, “Very often”, “Always”)

How often do the following things occur in your class(es)?

1. You offer personalized assignments to fit a particular student’s interests?
2. You offer personalized assignments to fit a particular student’s understanding of the material?
3. You offer personalized assignments to fit a particular student’s learning style?
4. You customize learning activities to address students’ abilities using digital tools and resources?

Authentic Learning. (Responses: “Never”, “Rarely”, “Sometimes”, “Very often”, “Always”)

How often do the following things occur in your class(es)?

1. You ask your students to use digital tools and resources to explore and solve real-world issues?
2. Your students complain about the relevance of their school work to their lives? (reverse-scored).

Collaborative Learning. (Responses: “Almost never”, “A few times a semester”, “1-3 times per month”, “1-3 times per week”, “Almost daily”)

In general, how often do you ask your students to do the following?

1. Work in pairs or small groups to complete a task together?
2. Work with other students to set goals and create a plan for their team?
3. Create joint projects using contributions from each student?
4. Present their group work to the class, teacher, or others?
5. Work as a team to incorporate feedback on group tasks or products?

The Cronbach’s alpha for each scale is approximately .892 for the teachers’ personalized learning scale, .853 for the teachers’ collaborative learning scale, and .609 for the teachers’ authentic learning scale.

Technology integration was measured by asking teachers “How often do your students use their 1:1 computing device in class?” with the response options “Less than once a week”, “1 day a week”, “2 days a week”, “3 days a week”, “4 days a week”, and “Every day”.

QIT Domains.

In order to obtain data on the implementation process in each school, Technology Integration Specialists (TISs) were interviewed about each school they oversaw using an interview designed to investigate all 5 out of 6 domains of the QIT; the sixth domain (Evaluate the effectiveness of the implementation) was largely the responsibility of the GTO team. The GTO team analyzed the responses and generated a succinct list of responses. Questions used in the survey and relevant responses are detailed below:

Develop an Implementation Team (Technology Leadership Teams)

1. During 2013-2014, did [school name] have an active technology leadership team? By active, we mean a team that has met at least once in person during the 2013-2014 year. (Yes, No)
2. Who is in charge of the technology leadership team? (No leader, Rotating, School Administrator, Technology Leadership Coach)
3. Describe the nature of the team. (e.g. what is their role in the school? Does the group simply provide feedback? Do they have decision making power?) (Don't know, Steering Committee, Advisory Group, Workgroup, Community/School coalition, other)
4. Describe the responsibilities of specific team members (other than the leader). (Don't know, No specific individual roles, Specific roles delineated)
5. How often does the team meet in person? (Never met, Once or twice in past year, Less than every other month, Every other month, At least once per month, more than once per month)

6. Did the technology leadership team meet virtually? (Don't know, Did not meet virtually, Instead of in person meetings, In addition to in person meetings)
7. How representative would you say that the team is in terms of teachers? (Don't know, Not representative, A little representative, Somewhat representative, Very representative)
8. Is administration actively involved in the technology leadership team meetings? (Don't know, Yes, No)

Foster a Supportive Climate (Practices and Procedures)

1. How supportive of 1TWO1 is administrative staff (e.g., Do they talk about the perceived need for and benefit of 1Two1? Have they created policies that enhance accountability around 1Two1?) (Don't know, Not at all supportive, A little supportive, Moderately supportive, Very supportive)
2. What practices and procedures, if any, existed in [school name] to deal with teacher resistance or pushback to technology integration during the 2013/2014 school year? (Don't know, No policies, Building relationships, Clear expectations, Focusing on teacher needs, Providing support)
3. Who, if anyone, are the leaders in the school in terms of championing ("cheerleading") 1TWO1 implementation (what is their position?)? (Don't know, TLC only, Administrator only, Another person (e.g. teacher), TLC and administration, More than 1 person)

4. What practices and procedures at [school name] support communication about 1TWO1? (Select all that apply: Don’t know, None, Meetings, Trainings, Media, Email, Surveys, Conversations)
5. Describe the ways in which [school name] communicated the perceived needs and benefits of 1TWO1 to teachers during the 2013/2014 school year. (Select all that apply: Don’t know, None, Emails, Meetings, Media, Training/Modeling, Evaluation, Conversations/Presentations)
6. What practices and procedures exist at [school name] that support teacher change—towards more personalize, authentic, and collaborative learning—in the classroom? (Select all that apply: Don’t know, None, PD/Training, Coaching, Principal support, Evaluation, Communication)

Implementation Plan

1. Did the school have an implementation plan? (Yes, No)
2. What did the implementation plan look like (did it have a timeline? Were tasks designated to certain people?) (None/Don’t know, District/GTO, Created/Not used, Timeline/Tasks)
3. How was the implementation plan used (was progress monitored on it? Was the plan revisited?)? (Don’t know, Didn’t monitor, Monitored but no change)

Professional Development

1. How has the school assessed teacher needs for 1TWO1-specific PD this past academic year? (Don't know/No plan, Needs assessed informally, Proactive plan)
2. How would you describe the quality of PD provided by the TLC? (NA, Poor, Needs improvement, Adequate, Good, Excellent)
3. Did the TLC tailor PD related to technology to the teacher's needs, including skill level and topic? (Disagree, In the middle, Agree, Strongly agree)
4. Did the TLC integrate new concepts and skills to familiar ideas so that teachers can learn them more easily? (Strongly disagree, Disagree, In the middle, Agree, Strongly Agree)
5. Did the TLC provide teachers with sufficient time to practice skills they learned in PD? (Strongly disagree, Disagree, In the middle, Agree, Strongly agree)
6. Was technology-related PD presented in an engaging and interesting format? (Strongly disagree, Disagree, In the middle, Agree, Strongly agree)
7. Were PD sessions at the school level supplemented by individual contact with the TLC? (Strongly disagree, Disagree, In the middle, Agree, Strongly agree)
8. Were teachers able to collaborate with each other and share and learn new ways to use technology? (Strongly disagree, Disagree, In the middle, Agree, Strongly agree)

9. Did teachers have regular opportunities to proved feedback about the quality of the PD that is provided to them? (Strongly disagree, Disagree, In the middle, Agree, Strongly agree)
10. What is the relationship between the TLC and the teachers (Are they well-liked? Respected?) (NA/Don't know, Good relationship, Very good relationship, Mixed, Bad)
11. In developing trainings, does the TLC understand school needs and available resources (For example, does the TLC provide PD on topics that are important to the teachers at the school? Is PD provided at an appropriate difficultly level for the teachers)? (Don't know/No, Yes)
12. How well does TLC understand the goals and objectives of 1TWO1? (Don't know, Has vague understanding, Pretty good understanding, Understands very well)
13. How often does the TLC provide 1:1 coaching (e.g., classroom observations and provide feedback)? (Don't know, Doesn't provide 1:1 coaching, When requested, Some teachers once a year, Some teachers once a semester)

Problem Solving

1. Does the TLC do more than the minimum required in terms of improving implementation of 1Two1 (e.g., does the TLC proactively collaborate with you?)? (Yes, No)
2. Does the TLC engage you in discussions and/or plans around problem solving? (Yes, No)

All answers were converted into numeric responses according to which answers the GTO team believed showed higher-quality implementation. Since each question had a different number of responses, each item was standardized into a z-score and then the questions were summed and standardized into a z-score again. The overall z-scores for each domain for each school were included in the model.

District Records.

District records were also obtained in order to examine students' academic standardized testing scores. The district provided records for all of the students in the district who had participated in standardized testing during the 2013-2014 school year. District records were obtained from district personnel with their consent in the Summer of 2014 and subsequently matched with the student survey dataset using student identification numbers. District data was able to be matched with student survey data with an approximately 80% success rate. There are various reasons students may not have been matched to their standardized test scores. One reason is they could have been absent on the day of testing. They could also have failed to be matched because they entered their student numbers incorrectly into the survey. Therefore, while the team obtained their survey data, this data was unable to be matched to district's records.

Measures in District Records. *Academic Achievement*. To examine students' academic achievement, the Measures of Academic Progress (MAP; https://www.nwea.org/assessments/map/) was collected for Reading and Math achievement the Fall of 2013 and Spring of 2014. MAP is an academic skills test administered to students in grades 3-8 in Richland School District 2 to help track their academic progress both between and within school years. Students are administered the MAP tests once in the Fall and once in the Spring each year and their results are used in a variety of ways—from academic planning to the referral of students for special education services. For the present study, the Rasch unit score (RIT) score will be used in order to build the model. The RIT scores provide an equal-interval scale that will be able to measure a student's growth over the course of the year. While RIT scores cannot be aggregated meaningfully due their being on a continuous scale such that students' scores should continue to increase as they move up in grade level, the current model will examine growth within students. In this way RIT scores are never aggregated.

Demographic Variables. Demographic information was also provided through district records. This information included School, Grade, Ethnicity, Gender, Free/Reduced Lunch status (a proxy of SES), and Special Education Status. All demographic variables entered into the analyses will be dichotomous such that Ethnicity will be coded as White or Non-white, SES will be coded as Free/Reduced or Not, and Special Education Status will be In Special Education or Not in Special Education. Demographic variables were matched with students' survey responses via their student identification number and where possible checked against their survey responses for Grade, Ethnicity, and School.

Learning.com 21st Century Skills Assessment.

In the Spring of 2014, Richland School District 2 administered the Learning.com 21st Century Skills Assessment (21CSA; http://www.learning.com/21st-century-skills-assessment/) to a final sample of 472 5th grade students and 271 8th grade students in the district. The 21CSA is an assessment administered by the Richland 2 School District at the recommendation of the GTO team. A district staff member controlled all aspects of test purchasing and administration and kept the GTO team informed throughout the process. An administrator located in the central office selected students at random from each school to take the assessment. The administrator randomly selected 30 5th grade students at each elementary school and 50 8th grade students from each middle school and the students were subsequently tested under the supervision of the Technology Learning Coordinator in each school. The 21CSA is a computer-based test that students can take online. District staff created students' profiles and students were able to login with their student numbers as their usernames. The test was administered over the course of two sessions on two separate days (usually on back-to-back days, with the longest gap being 3 days). The first school began testing on April 8th, 2014 and the final school completed testing on May 28th, 2014.

The 21CSA is a comprehensive assessment based on the NETS-S standards. As stated on their website,

> The 21st Century Skills Assessment uses a psychometrically validated blend of interactive, performance-based questions that allow students to authentically perform complex tasks in simulated applications, and multiple choice, knowledge-based questions. (http://www.learning.com/21st-century-skills-assessment/)

This assessment provides scores for each of the 6 NETS-S standards (Creativity and Innovation, Communication and Collaboration, Research and Information Fluency, Critical Thinking, Problem Solving and Decision Making, Digital Citizenship, and Technology Operations and Concepts) as well as an overall performance score. Scores can range from 100 to 500 and are deemed to be in one of four levels of proficiency: Below Basic (100-199), Basic (200-299), Proficient (300-399), and Advanced (400-500). For the current study, both students' subscale scores and overall proficiency scores will be utilized.

2.2 Data Analysis

Study 1: Examining School Satisfaction and Academic Outcomes.

School Satisfaction.

Both because of the clustered nature of the data and because of the research questions proposed, a multilevel model was used to analyze the data. First, an unconditional ANOVA model was fit for the outcome of school satisfaction in order to determine the amount of variance that was accounted for by clustering of students within schools. Next, a mixed-effects model was used to examine level 1 (Model 1) including all level 1 predictors as fixed effects and a random intercept in order to examine the effects of level 1 variables before examining the effects of the predictors aggregated at the school level. Next, Model 2 included the Level 1 predictors and the effects aggregated at the school level to determine the additional impact of overall levels of the predictors within each school. In addition to the various school-level factors, Model 2 also included the average SES in each school in order to account for possible differences in school resources.

Appropriate diagnostic procedures were conducted in order to ensure that model assumptions were not violated and that no school exerted undue influence on the overall model estimates. Examinations of model residuals indicated that the assumption of homoscedasticity of residuals was maintained. Examination of dfbetas and Cooks D indicated that no one school had undue leverage on the overall model.

All analyses were conducted in R version 3.1.2 with all models estimated using the nlme package and R^2 statistics were calculated based on the procedure outlined by Snijders and Bosker (1999).

Student-Reported Teaching Strategies.

The first model examined the impact of students' reports of their teachers' personalized, authentic, and collaborative learning as well as technology integration in the classroom on students' school satisfaction. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

Level 1

$Y_{ij} = \beta_{0j} + \beta_1(\text{GRADE})_{ij} + \beta_2(\text{SEX})_{ij} + \beta_3(\text{SES})_{ij} + \beta_4(\text{SPECIAL ED STATUS})_{ij} +$
$\beta_5(\text{RACE})_{ij} + \beta_6(\text{PERSONALIZED LEARNING})_{ij} + \beta_7(\text{AUTHENTIC LEARNING})_{ij} +$
$\beta_8(\text{COLLABORATIVE LEARNING})_{ij} + \beta_9(\text{COMPUTER USE})_{ij} + e_{ij}$

Level 2

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SCHOOL MEAN SES})_j + \gamma_{02}(\text{SCHOOL MEAN OF PERSONALIZED}$
$\text{LEARNING})_j + \gamma_{03}(\text{SCHOOL MEAN OF AUTHENTIC LEARNING})_j + \gamma_{04}(\text{SCHOOL}$
$\text{MEAN OF COLLABORATIVE LEARNING})_j + \gamma_{05}(\text{SCHOOL MEAN OF COMPUTER}$
$\text{USE})_j + u_{0j}$

Where students' school satisfaction was modeled at Level 1 as a function of their demographic characteristics (sex, SES, special education placement, and race) as well as their reports of their teachers' personalized, authentic, and collaborative learning strategies/styles and their computer use. In the Level 2 model, the Level 1 intercept is modeled as being a function of the aggregated overall level of students' perceptions of teachers' personalized, authentic, and collaborative teaching strategies, as well as the overall level of computer use at each school. While there are technically equations for each Level 1 parameter at Level 2, they are not shown here as they only consist of the fixed effect and were not modelled with random intercepts. All parameters were examined as fixed effects, since there are no hypothesized differences between the directions of the effect for different schools. Examinations of scatter plots for each predictor against the outcome indicated that there were no differences in the direction of the effect among schools.

Teacher-Reported Teaching Strategies.

The second model examined the impact of teachers' reports of their own teaching strategies on student school satisfaction. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

Level 1

$Y_{ij} = \beta_{0j} + \beta_1(\text{GRADE})_{ij} + \beta_2(\text{SEX})_{ij} + \beta_3(\text{SES})_{ij} + \beta_4(\text{SPECIAL ED STATUS})_{ij} +$

$\beta_5(\text{RACE})_{ij} + \beta_6(\text{PERSONALIZED LEARNING})_{ij} + \beta_7(\text{AUTHENTIC LEARNING})_{ij} +$

$\beta_8(\text{COLLABORATIVE LEARNING})_{ij} + \beta_9(\text{COMPUTER USE})_{ij} + e_{ij}$

Level 2

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SCHOOL MEAN SES})_j + \gamma_{02}(\text{SCHOOL MEAN OF PERSONALIZED}$

$\text{LEARNING})_j + \gamma_{03}(\text{SCHOOL MEAN OF AUTHENTIC LEARNING})_j + \gamma_{04}(\text{SCHOOL}$

MEAN OF COLLABORATIVE LEARNING$)_j + \gamma_{05}($SCHOOL MEAN OF COMPUTER USE$)_j + u_{0j}$

Where students' school satisfaction was modeled at Level 1 as described above and the Level 2 parameters are also the same except that they are teacher-reported means at each school rather than student-reported.

QIT Domains.

The third model is also similar to the models describe above, except that the Level 2 parameters are TIS-reported values for each QIT domain for each school. The final model equation (using the notation of Raudenbush and Bryck (2002)) is as follows:

Level 1

$Y_{ij} = \beta_{0j} + \beta_1($GRADE$)_{ij} + \beta_2(SEX)_{ij} + \beta_3(SES)_{ij} + \beta_4($SPECIAL ED STATUS$)_{ij} + \beta_5($RACE$)_{ij} + \beta_6($PERSONALIZED LEARNING$)_{ij} + \beta_7($AUTHENTIC LEARNING$)_{ij} + \beta_8($COLLABORATIVE LEARNING$)_{ij} + \beta_9($COMPUTER USE$)_{ij} + e_{ij}$

Level 2

$\beta_{0j} = \gamma_{00} + \gamma_{01}($SCHOOL MEAN SES$)_j + \gamma_{02}($IMPLEMENTATIN TEAM$)_j + \gamma_{03}($FOSTERING A SUPPORTIVE CLIMATE$)_j + \gamma_{04}($DEVELOPING AN IMPLEMENTATION PLAN$)_j + \gamma_{05}($TRAINING AND TECHNICAL ASSISTANCE$)_j + u_{0j}$

Students' school satisfaction was modeled at Level 1 as described. At Level 2, students' school satisfaction was modeled as a function of each school's score on the QIT domains as rated by the TISs.

English/Language Arts Scores.

The model used to examine the impact of technology-supported teaching strategies on students' changes in English/language arts scores is the same as the model that was used to examine students' school satisfaction scores. However, students' fall test scores were used as a covariate in order to examine the impact on the change in students' scores between the fall and spring test dates. Model 1 includes all of the individual-level predictors described above as well as students' fall test scores while Model 2 includes all of the school-level variables, including school-level SES, described above.

Student-Reported Teaching Strategies.

The first model examined the impact of students' reports of their teachers' personalized, authentic, and collaborative learning as well as technology integration in the classroom on changes in students' English/language arts test scores. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

<u>Level 1</u>

$Y_{ij} = \beta_{0j} + \beta_1(\text{FALL TEST SCORE})_{ij} + \beta_2(\text{GRADE})_{ij} + \beta_3(\text{SEX})_{ij} + \beta_4(\text{SES})_{ij} + \beta_5(\text{SPECIAL ED STATUS})_{ij} + \beta_6(\text{RACE})_{ij} + \beta_7(\text{PERSONALIZED LEARNING})_{ij} + \beta_8(\text{AUTHENTIC LEARNING})_{ij} + \beta_9(\text{COLLABORATIVE LEARNING})_{ij} + \beta_{10}(\text{COMPUTER USE})_{ij} + e_{ij}$

<u>Level 2</u>

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SCHOOL MEAN SES})_j + \gamma_{02}(\text{SCHOOL MEAN OF PERSONALIZED LEARNING})_j + \gamma_{03}(\text{SCHOOL MEAN OF AUTHENTIC LEARNING})_j + \gamma_{04}(\text{SCHOOL MEAN OF COLLABORATIVE LEARNING})_j + \gamma_{05}(\text{SCHOOL MEAN OF COMPUTER USE})_j + u_{0j}$

Students' spring English/language arts test scores were modeled at Level 1 as a function of their demographic characteristics (sex, SES, special education placement, and race), fall test scores, and their reports of their teachers' personalized, authentic, and collaborative learning strategies/styles and their computer use. In the Level 2 model, the Level 1 intercept is modeled as being a function of the aggregated overall level of students' perceptions of teachers' personalized, authentic, and collaborative teaching strategies, as well as the overall level of computer use at each school. While there are technically equations for each Level 1 parameter at Level 2, they are not shown here as they only consist of the fixed effect and were not modelled with random intercepts. All parameters were examined as fixed effects as there are no hypothesized differences between the directions of the effect for different schools. Examinations of scatter plots for each predictor against the outcome indicated that there were no differences in the direction of the effect among schools.

Teacher-Reported Teaching Strategies.

The second model examined the impact of teachers' reports of their own teaching strategies on students' changes in English/language arts test scores. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

Level 1

$Y_{ij} = \beta_{0j} + \beta_1(\text{FALL TEST SCORE})_{ij} + \beta_2(\text{GRADE})_{ij} + \beta_3(\text{SEX})_{ij} + \beta_4(\text{SES})_{ij} +$

$\beta_5(\text{SPECIAL ED STATUS})_{ij} + \beta_6(\text{RACE})_{ij} + \beta_7(\text{PERSONALIZED LEARNING})_{ij} +$

β_8(AUTHENTIC LEARNING)$_{ij}$ + β_9(COLLABORATIVE LEARNING)$_{ij}$ +

β_{10}(COMPUTER USE)$_{ij}$ + e_{ij}

<u>Level 2</u>

β_{0j}= γ_{00} + γ_{01}(SCHOOL MEAN SES)$_j$ +γ_{02}(SCHOOL MEAN OF PERSONALIZED LEARNING)$_j$ + γ_{03}(SCHOOL MEAN OF AUTHENTIC LEARNING)$_j$ + γ_{04}(SCHOOL MEAN OF COLLABORATIVE LEARNING)$_j$ + γ_{05}(SCHOOL MEAN OF COMPUTER USE)$_j$ + u_{0j}

Where students' spring English/language arts test scores were modeled at Level 1 as described above. The Level 2 parameters are also the same, as described above, except that they are teacher-reported means at each school rather than student-reported.

QIT Domains.

The third model is also similar to the models describe above, except that the Level 2 parameters are TIS-reported values for each QIT domain for each school. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

<u>Level 1</u>

Y_{ij}= β_{0j} + β_1(FALL TEST SCORE)$_{ij}$ + β_2(GRADE)$_{ij}$ + β_3(SEX)$_{ij}$ + β_4(SES)$_{ij}$ + β_5(SPECIAL ED STATUS)$_{ij}$ + β_6(RACE)$_{ij}$ + β_7(PERSONALIZED LEARNING)$_{ij}$ + β_8(AUTHENTIC LEARNING)$_{ij}$ + β_9(COLLABORATIVE LEARNING)$_{ij}$ + β_{10}(COMPUTER USE)$_{ij}$ + e_{ij}

<u>Level 2</u>

β_{0j}= γ_{00} + γ_{01}(SCHOOL MEAN SES)$_j$ + γ_{02}(IMPLEMENTATIN TEAM)$_j$ + γ_{03}(FOSTERING A SUPPORTIVE CLIMATE)$_j$ + γ_{04}(DEVELOPING AN

IMPLEMENTATION PLAN)$_j$ + γ_{05}(TRAINING AND TECHNICAL ASSISTANCE)$_j$ + u_{0j}

Students' spring English/language arts test scores were modeled at Level 1 as described above. At Level 2, English/language arts test scores were modeled as a function of each school's score on the QIT domains as rated by the TISs.

Mathematics Scores.

The model used to examine the impact of technology-supported teaching strategies on students' changes in Mathematics scores is the same as the model that was used to examine students' English/Language arts scores. Students' fall test scores were used as a covariate in order to examine the impact on the change in students' scores between the fall and spring test dates. Model 1 includes all of the individual-level predictors described above as well as students' fall test scores while Model 2 includes all of the school-level variables, including school-level SES, described above.

Student-Reported Teaching Strategies.

The first model examined the impact of students' reports of their teachers' personalized, authentic, and collaborative learning as well as technology integration in the classroom on changes in students' Mathematics test scores. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

<u>Level 1</u>

Y_{ij}= β_{0j} + β_1(FALL TEST SCORE)$_{ij}$ + β_2(GRADE)$_{ij}$ + β_3(SEX)$_{ij}$ + β_4(SES)$_{ij}$ + β_5(SPECIAL ED STATUS)$_{ij}$ + β_6(RACE)$_{ij}$ + β_7(PERSONALIZED LEARNING)$_{ij}$ +

β_8(AUTHENTIC LEARNING)$_{ij}$ + β_9(COLLABORATIVE LEARNING)$_{ij}$ + β_{10}(COMPUTER USE)$_{ij}$ + e_{ij}

Level 2

β_{0j}= γ_{00} + γ_{01}(SCHOOL MEAN SES)$_j$ +γ_{02}(SCHOOL MEAN OF PERSONALIZED LEARNING)$_j$ + γ_{03}(SCHOOL MEAN OF AUTHENTIC LEARNING)$_j$ + γ_{04}(SCHOOL MEAN OF COLLABORATIVE LEARNING)$_j$ + γ_{05}(SCHOOL MEAN OF COMPUTER USE)$_j$ + u_{0j}

Students' spring Mathematics test scores were modeled at Level 1 as a function of their demographic characteristics (sex, SES, special education placement, and race), fall test scores, and their reports of their teachers' personalized, authentic, and collaborative learning strategies/styles and their computer use. In the Level 2 model, the Level 1 intercept is modeled as being a function of the aggregated overall level of students' perceptions of teachers' personalized, authentic, and collaborative teaching strategies, as well as the overall level of computer use at each school. While there are technically equations for each Level 1 parameter at Level 2, they are not shown here as they only consist of the fixed effect and were not modelled with random intercepts. All parameters were examined as fixed effects as there are no hypothesized differences between the directions of the effect for different schools. Examinations of scatter plots for each predictor against the outcome indicated that there were no differences in the direction of the effect among schools.

Teacher-Reported Teaching Strategies.

The second model examined the impact of teachers' reports of their own teaching strategies on students' changes in Mathematics test scores. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

<u>Level 1</u>

$Y_{ij} = \beta_{0j} + \beta_1(\text{FALL TEST SCORE})_{ij} + \beta_2(\text{GRADE})_{ij} + \beta_3(\text{SEX})_{ij} + \beta_4(\text{SES})_{ij} + \beta_5(\text{SPECIAL ED STATUS})_{ij} + \beta_6(\text{RACE})_{ij} + \beta_7(\text{PERSONALIZED LEARNING})_{ij} + \beta_8(\text{AUTHENTIC LEARNING})_{ij} + \beta_9(\text{COLLABORATIVE LEARNING})_{ij} + \beta_{10}(\text{COMPUTER USE})_{ij} + e_{ij}$

<u>Level 2</u>

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SCHOOL MEAN SES})_j + \gamma_{02}(\text{SCHOOL MEAN OF PERSONALIZED LEARNING})_j + \gamma_{03}(\text{SCHOOL MEAN OF AUTHENTIC LEARNING})_j + \gamma_{04}(\text{SCHOOL MEAN OF COLLABORATIVE LEARNING})_j + \gamma_{05}(\text{SCHOOL MEAN OF COMPUTER USE})_j + u_{0j}$

Where students' spring English/language arts test scores were modeled at Level 1 as described above. The Level 2 parameters are also the same, as described above, except that they are teacher-reported means at each school rather than student-reported.

QIT Domains.

The third model is also similar to the models describe above, except that the Level 2 parameters are TIS-reported values for each QIT domain for each school. The final model equation (using the notation of Raudenbush and Bryck (2002)) is:

Level 1

$Y_{ij} = \beta_{0j} + \beta_1(\text{FALL TEST SCORE})_{ij} + \beta_2(\text{GRADE})_{ij} + \beta_3(\text{SEX})_{ij} + \beta_4(\text{SES})_{ij} +$

$\beta_5(\text{SPECIAL ED STATUS})_{ij} + \beta_6(\text{RACE})_{ij} + \beta_7(\text{PERSONALIZED LEARNING})_{ij} +$

$\beta_8(\text{AUTHENTIC LEARNING})_{ij} + \beta_9(\text{COLLABORATIVE LEARNING})_{ij} +$

$\beta_{10}(\text{COMPUTER USE})_{ij} + e_{ij}$

Level 2

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SCHOOL MEAN SES})_j + \gamma_{02}(\text{IMPLEMENTATIN TEAM})_j +$

$\gamma_{03}(\text{FOSTERING A SUPPORTIVE CLIMATE})_j + \gamma_{04}(\text{DEVELOPING AN}$

$\text{IMPLEMENTATION PLAN})_j + \gamma_{05}(\text{TRAINING AND TECHNICAL ASSISTANCE})_j +$

u_{0j}

Students' spring Mathematics test scores were modeled at Level 1 as described above. At Level 2, students' Mathematics test scores were modeled as a function of each school's score on the QIT domains as rated by the TISs.

Study 2: Examining 21st Century Learning Outcomes.

In order to examine the relationship between student-reported teachers' technology-supported teaching strategies and students' scores on the 21st Century Skills Assessment, multiple regression analyses were conducted. The analyses used all six subscale scores (Creativity and Innovation, Communication and Collaboration, Research and Information Fluency, Critical Thinking Problem Solving and Decision Making, Digital Citizenship, and Technology Operations and Concepts) as well as their overall score as the outcome variables. Each of these scales was regressed on students' sex, race (run dichotomously as 0=White, 1=Non-White), and SES (0=Paid lunch, 1=Free/Reduced Lunch) in addition to students' reports of their teachers' use of

Personalized, Authentic, and Collaborative learning strategies and the number of days per week they used a computer (Computer Use). Analyses were conducted separately for the Elementary School (5^{th} grade) and Middle School (8^{th} grade) samples. Students with missing data from their survey responses were not included in the final analyses. Therefore the sample consisted of 372 Elementary School students (78.8% of the total number who completed the 21^{st} Century Skills Assessment) and 198 Middle School students (73.1% of the total number who completed the 21^{st} Century Skills Assessment)

All analyses were analyzed using Mplus version 6.12. All analyses were run simultaneously in order to control for possible multiple comparisons.

CHAPTER 3

RESULTS

3.1 Study 1: Examining School Satisfaction and Academic Outcomes

Descriptive Statistics

Sample descriptive statistics were calculated for all independent and outcome variables and are displayed in table 3.1. For the purposes of the three outcomes investigated, the Overall teaching strategy variables (an average of the ELA and Math teaching strategy variables) were used in the school satisfaction analyses while the ELA and Math teaching strategy variables were used in the ELA and Math analyses respectively.

School Satisfaction.

Student-Reported Teaching Strategies.

Estimates for the predictors of school satisfaction are displayed in Table 3.2. In Model 1, students' grade, sex, SES, and their perceptions of teachers' personalized, authentic, and collaborative learning strategies were found to be significantly related to students' school satisfaction. These results indicate that students' school satisfaction declined by .186 units per year on average (replicating a phenomenon described above). They also indicated that females' level of school satisfaction was .131 units higher than males and that higher SES students' school satisfaction was .066 standard deviation units higher than lower SES students. The effects for grade and sex were significant at the $p<.001$ level and the effect of SES was significant at the $p<.01$ level.

Table 3.1 Sample Descriptive Statistics

	Mean	SD
Outcome Variables		
School Satisfaction	5.08	1.18
Fall MAP ELA Scores	210.72	16.73
Spring MAP ELA Scores	215.84	15.31
Fall MAP Math Scores	215.66	18.56
Spring MAP Math Scores	221.48	17.81
Teaching Strategies		
ELA Personalized	3.43	1.01
ELA Authentic	3.66	1.00
ELA Collaborative	2.67	0.86
Math Personalized	3.41	1.05
Math Authentic	3.67	1.04
Math Collaborative	2.35	0.96
Overall Personalized	3.42	0.87
Overall Authentic	3.67	0.86
Overall Collaborative	2.51	0.79

Table 3.2. School Satisfaction Analyses (Student Report)

Variable	Model 1		Model 2	
	Coefficient	SE	Coefficient	SE
Intercept	6.058***	.074	6.036***	.080
Level 1 Variables				
Grade	-.186***	.013	-.182***	.014
Sex	.131***	.023	.130***	.023
Race	.049	.028	.052	.028
Special Ed.	-.053	.048	-.054	.048
SES	-.066**	.025	-.063**	.025
Personalized Learning	.238***	.019	.238***	.019
Authentic Learning	.285***	.018	.285***	.018
Collaborative Learning	-.043*	.017	-.043*	.017
Computer Use	-.002	-.018	-.001	.018
Level 2 Variables (Student Report)				
Average School SES			-.003	.002
Avg. School Personalized Learning			.243	.530
Avg. School Authentic Learning			-.201	.506
Avg. School Collaborative Learning			.121	.214
Avg. School Computer Use			-.186	.139
Level 1 R^2	.207		.203	
Level 2 R^2			.572	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=8047
*= p<.05, **=p<.01 ***=p<.001

In terms of teachers' technology-related learning strategies, students' reports indicated that for every 1 standard deviation increase in the reported use of authentic learning strategies, students' school satisfaction increased by .285 points and that for every 1 standard deviation unit increase in the use of personalized learning strategies, students' school satisfaction increased by .238 points. Both of these effects were significant at the $p<.001$ level. Interestingly, students reported that for every 1 standard deviation increase in their teachers' use of collaborative learning strategies, their school satisfaction dropped by .043 points and this effect was significant at the $p<.05$ level. There was no significant relationship between students' individual computer use and school satisfaction. The standard deviation of the random effect for Model 1 was 0.155 with a residual of 1.034. The Level 1 R^2 value for Model 1 indicates that the model accounted for approximately 20.7% more of the variance than the unconditional model. Additional analyses revealed that approximately 7.8% of the Level 1 R^2 value was due to the addition of the technology-related teaching strategy variables.

Model 2 included students' ratings of teachers' technology-supported teaching strategies and the overall levels of teachers' technology-supported teaching strategies for each school as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES, schools' mean levels of teachers' technology-supported teaching strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 20.3% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 57.2% of the between-school variance. The standard deviation for the random effect for Model 2 was 0.160 with a residual of 1.034.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 1 was also a better fit than Model 2 ($p<.05$; see table 3.3). Thus the school-level predictors did not improve the overall fit of the model.

Teacher-Reported Teaching Strategies.

The results for Model 1 are exactly the same as those described above, therefore only the Model 2 results are discussed. Please see Table 3.4 for the values of the coefficients.

Model 2 included the level of students' teachers' technology-supported teaching strategies and the overall levels of teachers' technology-supported teaching strategies for each school, as reported by teachers, as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES, schools' mean levels of teachers' technology-supported teaching strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 19.7% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 54.9% of the between-school variance. The standard deviation for the random effect for Model 2 was 0.169 with a residual of 1.034.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 1 was also a better fit than Model

Table 3.3. School Satisfaction Models (Student Report)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	24763.6	24784.6	-12378.8	-	-
Model 1 (only individual-level predictors)	23500.8	23584.7	-11738.4	1 v. 2	<.0001
Model 2 (with school-level predictors)	23522.1	23640.9	-11744.0	2 v. 3	0.047

Table 3.4. School Satisfaction Analyses (Teacher Report)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	6.058***	.074	5.916***	1.109
Level 1 Variables				
Grade	-.186***	.013	-.188***	.014
Sex	.131***	.023	.131***	.023
Race	.049	.028	.052	.028
Special Ed.	-.053	.048	-.053	.048
SES	-.066**	.025	-.063*	.025
Personalized Learning	.238***	.019	.238***	.019
Authentic Learning	.285***	.018	.285***	.018
Collaborative Learning	-.043*	.017	-.042*	.017
Computer Use	-.002	-.018	-.002	.018
Level 2 Variables (Teacher Report)				
Average School SES			-.002	.002
Avg. School Personalized Learning			-.136	.344
Avg. School Authentic Learning			.244	.375
Avg. School Collaborative Learning			-.036	.205
Avg. School Computer Use			-.017	.084
Level 1 R^2	.207		.197	
Level 2 R^2			.549	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=7737
*= p<.05, **=p<.01 ***=p<.001

2 ($p<.05$; see Table 3.5). Thus the school-level predictors did not improve the overall fit of the model.

QIT Domains.

Despite the removal of two schools who were missing data for the QIT domains, the results from Model 1 were consistent with the results reported earlier. Therefore, only Model 2 will be discussed. For the values of the coefficients, please see Table 3.6.

Model 2 included the level of students' teachers' technology-supported teaching strategies and the values of each QIT domain for each school as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES, schools' mean levels of teachers' technology-supported teaching strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 21.3% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 53.8% of the between-school variance. The standard deviation for the random effect for Model 2 was 0.141 with a residual of 1.036.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 1 was also a better fit than Model 2 ($p<.001$; see Table 3.7). Thus the school-level predictors did not improve the overall fit of the model.

Table 3.5. School Satisfaction Models (Teacher Report)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	24763.6	24784.6	-12378.8	-	-
Model 1 (only individual-level predictors)	23500.8	23584.7	-11738.4	1 v. 2	<.0001
Model 2 (with school-level predictors)	23525.7	23644.1	-11745.8	2 v. 3	0.011

Table 3.6. School Satisfaction Analyses (QIT Domains)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	6.030***	.072	6.033***	.081
Level 1 Variables				
Grade	-.183***	.012	-.184***	.014
Sex	.131***	.024	.131***	.024
Race	.053	.028	.053	.028
Special Ed.	-.047	.049	-.046	.049
SES	-.065*	.026	-.065*	.026
Personalized Learning	.242***	.019	.242***	.020
Authentic Learning	.289***	.019	.288***	.019
Collaborative Learning	-.046**	.017	-.045**	.017
Computer Use	-.004	-.018	-.005	.018
Level 2 Variables				
Average School SES			-.000	.002
Technology Leadership Teams			-.008	.007
Practices and Procedures			.004	.013
Implementation Plan			-.003	.016
Professional Development			-.005	.005
Problem Solving			.023	.029
Level 1 R^2	.223		.213	
Level 2 R^2			.538	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=8047
*= p<.05, **=p<.01 ***=p<.001

Table 3.7. School Satisfaction Models (QIT Domains)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	24763.6	24784.6	-12378.8	-	-
Model 1 (only individual-level predictors)	22614.8	22698.2	-11295.4	1 v. 2	<.0001
Model 2 (with school-level predictors)	22672.2	22797.3	-11318.1	2 v. 3	<.0001

English/Language Arts Test Scores.

Student-Reported Teaching Strategies.

Estimates for the predictors of students' spring English/language arts scores are displayed in Table 3.8. In Model 1, students' fall test scores, race, special education status, SES, and their perceptions of teachers' authentic and collaborative learning strategies were found to be significantly related to students' English/language arts scores. These results indicate that white students' English/language arts test scores increased every year, on average, 1.18 points more than non-white students, regular education students' English/language arts test scores increased every year, on average, 1.97 points more than special education students, and that higher SES students' English/language arts test scores increased every year, on average, 1.54 points more than lower SES students. The effects for race, special education status, and SES were all significant at $p<.001$.

In terms of teachers' technology-related learning strategies, students' reports indicated that for every 1 standard deviation increase in the use of authentic learning strategies, students' English/language arts test scores increased by .283 points, which was significant at the $p<.01$ level. There was no significant relationship students' reports of teachers' personalized or collaborative learning strategies, or individual computer use and changes in English/Language arts test scores. The standard deviation of the random effect for Model 1 was 0.977 with a residual of 7.041. The Level 1 R^2 value for Model 1 indicates that the model accounted for approximately 60.3% more of the variance than the unconditional model.

Model 2 included the level of students' teachers' technology-supported teaching strategies and the overall levels of teachers' technology-supported

Table 3.8. ELA Score Analyses (Student Report)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	54.601***	1.318	54.517***	1.334
Level 1 Variables				
Fall Test Scores	.773***	.006	.773***	.006
Sex	.169	.166	.169	.166
Race	-1.179***	.200	-1.172***	.200
Special Ed.	-1.968***	.342	-1.969***	.342
SES	-1.536***	.187	-1.522***	.187
Personalized Learning	-.158	.111	-.153	.111
Authentic Learning	.283*	.110	.278*	.111
Collaborative Learning	-.206	.107	-.205	.108
Computer Use	.078	.130	.099	.132
Level 2 Variables (Student Report)				
Average School SES			.005	.013
Avg. School Personalized Learning			-3.440	2.841
Avg. School Authentic Learning			2.703	2.473
Avg. School Collaborative Learning			.563	1.187
Avg. School Computer Use			-.535	.907
Level 1 R^2	.603		.603	
Level 2 R^2			.853	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=7396
*= p<.05, **=p<.01 ***=p<.001

teaching strategies for each school, as reported by students, as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES, schools' mean levels of teachers' technology-supported teaching strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 60.3% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 85.3% of the between-school variance. The standard deviation for the random effect for Model 2 was 1.043 with a residual of 7.041.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 2 did not provide a better fit than Model 1 (see Table 3.9). Thus the school-level predictors did not improve the overall fit of the model.

Teacher-Reported Teaching Strategies.

The results for Model 1 are exactly the same as those described above, therefore only the Model 2 results are discussed. Please see Table 3.10 for the values of the coefficients.

Model 2 included the level of students' teachers' technology-supported teaching strategies and the overall levels of teachers' technology-supported teaching strategies for each school, as reported by teachers, as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES, schools' mean levels of

Table 3.9. ELA Score Models (Student Report)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	59861.4	59882.1	-29927.7	-	-
Model 1 (only individual-level predictors)	49944.4	50027.3	-24960.2	1 v. 2	<.0001
Model 2 (with school-level predictors)	49949.8	50067.2	-24957.9	2 v. 3	0.4628

Table 3.10. ELA Score Analyses (Teacher Report)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	54.483***	1.318	54.525***	1.317
Level 1 Variables				
Fall Test Scores	.774***	.006	.774***	.006
Sex	.142	.165	.144	.165
Race	-1.183***	.199	-1.177***	.200
Special Ed.	-2.050***	.338	-2.057***	.338
SES	-1.504***	.186	-1.500***	.187
Personalized Learning	-.150	.110	-.150	.110
Authentic Learning	.272*	.110	.273*	.110
Collaborative Learning	-.204	.107	-.209	.107
Computer Use	.068	.129	.072	.129
Level 2 Variables (Teacher Report)				
Average School SES			.004	.014
Avg. School Personalized Learning			-3.038	2.103
Avg. School Authentic Learning			4.187	2.307
Avg. School Collaborative Learning			.540	1.251
Avg. School Computer Use			.070	.521
Level 1 R^2	.604		.604	
Level 2 R^2			.843	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=7396
*= p<.05, **=p<.01 ***=p<.001

teachers' technology-supported teaching strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 60.4% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 84.3% of the between-school variance. The standard deviation for the random effect for Model 2 was 1.004 with a residual of 7.039.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 2 did not provide a better fit than Model 1 (see Table 3.11). Thus the school-level predictors did not improve the overall fit of the model.

QIT Domains.

With the removal of two schools, the results for Model 1 did not change, therefore only the Model 2 results are discussed. Please see Table 3.12 for the values of the coefficients.

Model 2 included the level of students' teachers' technology-supported teaching strategies and the values of each QIT domain for each school as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES or any of the QIT domains. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 59.5% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 83.7% of the

Table 3.11. ELA Score Models (Teacher Report)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	60544.6	60565.3	-30269.3	-	-
Model 1 (only individual-level predictors)	50466.8	50549.8	-25221.4	1 v. 2	<.0001
Model 2 (with school-level predictors)	50470.9	50588.5	-25218.5	2 v. 3	0.320

Table 3.12. ELA Score Analyses (QIT Domains)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	54.834***	1.328	54.852***	1.351
Level 1 Variables				
Fall Test Scores	.773***	.006	.772***	.006
Sex	.102	.168	.103	.168
Race	-1.173***	.201	-1.188***	.202
Special Ed.	-2.117***	.344	-2.113***	.345
SES	-1.434***	.189	-1.446***	.190
Personalized Learning	-.111	.113	-.110	.113
Authentic Learning	.228*	.113	.224*	.113
Collaborative Learning	-.180	.109	-.181	.109
Computer Use	.050	.132	.056	.133
Level 2 Variables (Student Report)				
Average School SES			-.005	.013
Technology Leadership Teams			-.014	.048
Practices and Procedures			-.022	.088
Implementation Plan			.060	.106
Professional Development			.003	.036
Problem Solving			.123	.193
Level 1 R^2	.600		.595	
Level 2 R^2			.837	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=7206
*= p<.05, **=p<.01 ***=p<.001

between-school variance. The standard deviation for the random effect for Model 2 was 0.954 with a residual of 7.039.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and Model 2 did not provide a better fit than Model 1 (see Table 3.13). Thus the school-level predictors did not improve the overall fit of the model.

Math Test Scores.

Student-Reported Teaching Strategies.

Estimates for the predictors of students' spring Math scores are displayed in Table 3.14. In Model 1, students' fall test scores, race, special education status, SES, and their perceptions of teachers' authentic and collaborative learning strategies as well as computer use were found to be significantly related to students' changes in Math scores. These results indicate that male students' Math test scores increased .54 points more than female students', white students' Math test scores increased every year, on average, 1.24 points more than non-white students, regular education students' Math test scores increased every year, on average, 1.35 points more than special education students, and that higher SES students' Math test scores increased every year, on average, 1.17 points more than lower SES students. The effects for sex, race, special education status, and SES were all significant at the $p<.001$ level.

In terms of teachers' technology-related learning strategies, students' reports indicated that for every 1 standard deviation increase in the use of authentic learning strategies, students' Math test scores increased by .304 points and that for each standard

Table 3.13. ELA Score Models (QIT Domains)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	58375.9	58396.5	-29184.9	-	-
Model 1 (only individual-level predictors)	48650.8	48733.4	-24313.4	1 v. 2	<.0001
Model 2 (with school-level predictors)	48685.5	48809.4	-24324.8	2 v. 3	9e-04

Table 3.14. Math Score Analyses (Student Report)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	27.179***	1.286	27.179***	1.286
<u>Level 1 Variables</u>				
Fall Test Scores	.916***	.005	.918***	.005
Sex	-.536***	.154	-.540***	.154
Race	-1.238***	.188	-1.231***	.188
Special Ed.	-1.349***	.312	-1.325***	.312
SES	-1.171***	.175	-1.155***	.175
Personalized Learning	-.078	.100	-.081	.100
Authentic Learning	.304**	.096	.296**	.096
Collaborative Learning	-.340***	.092	-.337***	.092
Computer Use	.314**	.119	.331**	.119
<u>Level 2 Variables (Student Report)</u>				
Average School SES			-.036	.021
Avg. School Personalized Learning			-6.869*	3.259
Avg. School Authentic Learning			14.665***	3.535
Avg. School Collaborative Learning			-4.127	4.937
Avg. School Computer Use			.009	1.258
Level 1 R^2	.625		.666	
Level 2 R^2			.808	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=7099
*= p<.05, **=p<.01 ***=p<.001

deviation increase in students' reported computer use students' Math test scores increased by .314 points. Both of these effects were significant at the $p<.01$ level. Interestingly, students reported that for every 1 standard deviation increase in their teachers' use of collaborative learning strategies, Math test scores decreased by .340 points and this effect was significant at the $p<.001$ level. The standard deviation of the random effect for Model 1 was 2.469 with a residual of 6.404. The Level 1 R^2 value for Model 1 indicates that the model accounted for approximately 62.5% more of the variance than the unconditional model.

Model 2 included the overall levels of teachers' technology-supported teaching strategies for each school, as reported by students, as well as the overall SES of each school. The model indicated that for each standard deviation increase in the school's mean level of teachers' use of authentic learning strategies, students' Math test scores increased by 14.67 points and this was significant at the $p<.001$ level. There were no significant effects found for schools' mean SES, schools' mean levels of personalized learning strategies, collaborative learning strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 66.6% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 80.8% of the between-school variance. The standard deviation for the random effect for Model 2 was 1.502 with a residual of 6.404.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 2 was a significantly better fit than

Model 1 ($p<.001$; see Table 3.15). Thus the school-level predictors improved the overall fit of the model.

Teacher-Reported Teaching Strategies.

The results for Model 1 are exactly the same as those described above, therefore only the Model 2 results are discussed. Please see Table 3.16 for the values of the coefficients.

Model 2 included the mean overall levels of teachers' technology-supported teaching strategies for each school, as reported by teachers, as well as the overall SES of each school. The model indicated that there were no additional significant effects. There were no significant effects found for schools' mean SES, schools' mean levels of teachers' technology-supported teaching strategies, or average school computer use. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 64.2% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 73.5% of the between-school variance. The standard deviation for the random effect for Model 2 was 2.094 with a residual of 6.412.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and that Model 2 did not provide a better fit than Model 1 (see Table 3.17). Thus the school-level predictors did not improve the overall fit of the model.

Table 3.15. Math Score Models (Student Report)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	59418.1	59438.8	-29706.1	-	-
Model 1 (only individual-level predictors)	46641.9	46724.3	-23308.9	1 v. 2	<.0001
Model 2 (with school-level predictors)	46615.9	46732.7	-23291.0	2 v. 3	<.0001

Table 3.16. Math Score Analyses (Teacher Report)

	Model 1		Model 2	
Variable	Coefficient	SE	Coefficient	SE
Intercept	27.254***	1.281	27.153***	1.257
<u>Level 1 Variables</u>				
Fall Test Scores	.916***	.005	.916***	.005
Sex	-.561***	.153	-.560***	.153
Race	-1.225***	.188	-1.218***	.188
Special Ed.	-1.452***	.308	-1.450***	.308
SES	-1.157***	.174	-1.145***	.174
Personalized Learning	-.098	.099	-.099	.099
Authentic Learning	.308**	.095	.306**	.095
Collaborative Learning	-.347***	.091	-.347***	.091
Computer Use	.291*	.118	.295*	.118
<u>Level 2 Variables (Teacher Report)</u>				
Average School SES			-.009	.118
Avg. School Personalized Learning			-2.467	4.020
Avg. School Authentic Learning			8.267	4.367
Avg. School Collaborative Learning			3.829	2.367
Avg. School Computer Use			.160	.989
Level 1 R^2	.626		.642	
Level 2 R^2			.735	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=7177
*= p<.05, **=p<.01 ***=p<.001

Table 3.17. Math Score Models (Teacher Report)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	60083.7	60104.3	-30038.8	-	-
Model 1 (only individual-level predictors)	47171.7	47254.2	-2357.8	1 v. 2	<.0001
Model 2 (with school-level predictors)	47161.0	47277.9	-23563.5	2 v. 3	9e-04

QIT Domains.

With the removal of two schools, the results for Model 1 are exactly the same as those described above, therefore only the Model 2 results are discussed. Please see Table 3.18 for the values of the coefficients.

Model 2 included the values of each QIT domain for each school as well as the overall SES of each school. The model indicated that for each standard deviation increase in the school's quality of professional development, students' math scores increased by .245 points and this was significant at the $p<.01$ level. There were no additional significant effects found for schools' mean SES or any of the other QIT domains. The Level 1 R^2 for Model 2 indicated that the model accounted for approximately 62.8% more of the student-level variance than the unconditional model and the Level 2 R^2 indicated that the model accounted for approximately 69.9% of the between-school variance. The standard deviation for the random effect for Model 2 was 2.192 with a residual of 6.440.

Global tests of overall model fit found that Model 1 was a significantly better fit than the unconditional model ($p<.001$) and Model 2 did not provide a better fit than Model 1 (see Table 3.19). Thus the QIT domain predictors did not improve the overall fit of the model.

3.2 Study 2: Examining 21st Century Learning Outcomes

Descriptive Statistics.

Prior to conducting regression analyses, histograms were plotted to test the normality of each outcome variable. All variables were within acceptable limits of

Table 3.18. Math Score Analyses (QIT Domains)

Variable	Model 1 Coefficient	Model 1 SE	Model 2 Coefficient	Model 2 SE
Intercept	25.868***	1.328	25.304***	1.319
Level 1 Variables				
Fall Test Scores	.922***	.006	.923***	.006
Sex	-.539***	.157	-.539***	.157
Race	-1.203***	.191	-1.197***	.191
Special Ed.	-1.337***	.316	-1.325***	.316
SES	-1.093***	.177	-1.086***	.177
Personalized Learning	-.104	.101	-.106	.101
Authentic Learning	.317**	.097	.314**	.097
Collaborative Learning	-.327***	.094	-.326***	.094
Computer Use	.333**	.122	.340**	.122
Level 2 Variables (QIT Domains)				
Average School SES			-.004	.028
Technology Leadership Teams			-.084	.103
Practices and Procedures			.144	.183
Implementation Plan			-.275	.225
Professional Development			.245**	.078
Problem Solving			-.805	.406
Level 1 R^2	.612		.628	
Level 2 R^2			.699	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for Special Education Status, 0=Not in Special Education, 1= In Special Education; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch; Average School SES represents % on Free/Reduced Price Lunch.
N=6912
*= p<.05, **=p<.01 ***=p<.001

Table 3.19. Math Score Models (QIT Domains)

Model	AIC	BIC	LogLik	Test	p-value
Unconditional Model	57964.4	57984.9	-28979.2	-	-
Model 1 (only individual-level predictors)	45490.5	45572.5	-22733.2	1 v. 2	<.0001
Model 2 (with school-level predictors)	45504.8	45627.9	-22734.4	2 v. 3	.8867

normality. Tables 3.20 and 3.21 present the means and standard deviations (SD) for all outcome variables assessed.

21st Century Skills Analyses

As analyses were run separately on the elementary school and middle school samples, please see Table 3.22 for the values of the Elementary School analyses and Table 3.23 for the Middle School analyses.

Creativity and Innovation.

In the Elementary School analyses, Race, SES, Sex, and Collaborative learning were found to be significant predictors of students' Creativity and Innovation score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .170 standard deviations higher than non-white students, higher SES students' scores were .188 standard deviations higher than lower SES students' scores, and female students' scores were .109 standard deviations higher than male students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their Creativity and Innovation scores decreased by .120 standard deviations. The R^2 for the model indicated that the model accounted for approximately 12.0% of the variance in students' Creativity and Innovation scores.

In the Middle School analyses, only Race and SES were found to be significant predictors of students' Creativity and Innovation scores. Specifically, white students scored .169 standard deviations higher than non-white students and higher SES students scored .238 standard deviation units higher than lower SES students. The R^2 for the

Table 3.20. 21CSA Descriptive Statistics- Elementary School

Variable	Mean	SD
Creativity and Innovation	318.69	97.48
Communication and Collaboration	336.22	80.57
Research and Information Fluency	306.79	83.05
Critical Thinking, Problem Solving, and Decision Making	319.22	93.90
Digital Citizenship	335.75	93.43
Technology Operations and Concepts	323.54	92.81
Total Score	332.64	74.89

Table 3.21. 21CSA Descriptive Statistics- Middle School

Variable	Mean	SD
Creativity and Innovation	297.22	84.26
Communication and Collaboration	298.65	87.53
Research and Information Fluency	281.76	77.41
Critical Thinking, Problem Solving, and Decision Making	293.68	73.08
Digital Citizenship	303.69	79.18
Technology Operations and Concepts	291.16	79.67
Total Score	298.14	61.87

Table 3.22. 21st Century Elementary School Analyses

Variable	Standardized Estimate	Standard Error	R^2
Creativity and Innovation			.120
Intercept	3.681***	.134	
Sex	.109*	.048	
Race	-.170***	.048	
SES	-.188***	.050	
Personalized Learning	-.090	.056	
Authentic Learning	.065	.053	
Collaborative Learning	-.120*	.052	
Computer Use	.012	.053	
Communication and Collaboration			.119
Intercept	4.569***	.178	
Sex	.072	.049	
Race	-.144*	.048	
SES	-.186***	.051	
Personalized Learning	-.070	.054	
Authentic Learning	.086	.053	
Collaborative Learning	-.154**	.051	
Computer Use	-.066	.049	
Research and Information Fluency			.133
Intercept	4.101***	.152	
Sex	.056	.048	
Race	-.130**	.053	
SES	-.221***	.052	
Personalized Learning	.024	.057	
Authentic Learning	.002	.057	
Collaborative Learning	-.192***	.048	
Computer Use	.080	.056	
Critical Thinking, Problem Solving, and Decision Making			.142
Intercept	3.941***	.141	
Sex	.086	.048	
Race	-.242***	.051	
SES	-.154**	.051	
Personalized Learning	-.027	.058	
Authentic Learning	.044	.056	
Collaborative Learning	-.146**	.050	
Computer Use	-.026	.044	

Variable	Standardized Estimate	Standard Error	R^2
Digital Citizenship			.104
Intercept	3.956	.141	
Sex	.072	.049	
Race	-.184***	.050	
SES	-.108*	.052	
Personalized Learning	-.110	.059	
Authentic Learning	.096	.056	
Collaborative Learning	-.149**	.050	
Computer Use	-.018	.059	
Technology Operations and Concepts			.173
Intercept	3.468***	.178	
Sex	.094*	.047	
Race	-.156***	.051	
SES	-.128**	.052	
Personalized Learning	-.029	.063	
Authentic Learning	-.018	.057	
Collaborative Learning	-.145**	.047	
Computer Use	-.260***	.064	
Overall Score			.160
Intercept	4.903***	.181	
Sex	.093*	.047	
Race	-.206***	.048	
SES	-.197***	.051	
Personalized Learning	-.061	.055	
Authentic Learning	.059	.054	
Collaborative Learning	-.181***	.049	
Computer Use	-.015	.055	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch.
N=371
*= p<.05, **=p<.01 ***=p<.001

Table 3.23. 21st Century Middle School Analyses

Variable	Standardized Estimate	Standard Error	R^2
Creativity and Innovation			.136
Intercept	3.822***	.772	
Sex	.039	.068	
Race	-.169*	.070	
SES	-.238***	.070	
Personalized Learning	-.019	.099	
Authentic Learning	.008	.096	
Collaborative Learning	-.110	.074	
Computer Use	.013	.069	
Communication and Collaboration			.118
Intercept	3.175***	.782	
Sex	.067	.069	
Race	-.053	.072	
SES	-.283***	.070	
Personalized Learning	.074	.100	
Authentic Learning	-.057	.097	
Collaborative Learning	-.091	.075	
Computer Use	.046	.069	
Research and Information Fluency			.133
Intercept	3.002***	.781	
Sex	.013	.068	
Race	-.179*	.070	
SES	-.188**	.071	
Personalized Learning	-.088	.099	
Authentic Learning	.081	.096	
Collaborative Learning	-.141	.074	
Computer Use	.099	.068	
Critical Thinking, Problem Solving, and Decision Making			.124
Intercept	3.745***	.788	
Sex	-.033	.069	
Race	-.215**	.070	
SES	-.152*	.071	
Personalized Learning	-.174	.099	
Authentic Learning	.082	.097	
Collaborative Learning	-.042	.075	
Computer Use	.065	.069	

Variable	Standardized Estimate	Standard Error	R^2
Digital Citizenship			.132
Intercept	3.811***	.780	
Sex	-.026	.068	
Race	-.123	.071	
SES	-.278***	.069	
Personalized Learning	.003	.100	
Authentic Learning	-.048	.096	
Collaborative Learning	-.041	.074	
Computer Use	.045	.069	
Technology Operations and Concepts			.127
Intercept	3.318***	.782	
Sex	-.014	.069	
Race	-.162*	.071	
SES	-.244***	.070	
Personalized Learning	-.065	.100	
Authentic Learning	.006	.097	
Collaborative Learning	.025	.074	
Computer Use	.076	.069	
Overall Score			.172
Intercept	4.607***	.779	
Sex	.024	.067	
Race	-.181**	.069	
SES	-.277***	.068	
Personalized Learning	-.060	.097	
Authentic Learning	.012	.094	
Collaborative Learning	-.081	.072	
Computer Use	.066	.067	

Note. For sex, 0=Male, 1=Female; for race, 0=White, 1=Non-white; for SES, 0=Paid Lunch, 1=Free/Reduced Price Lunch.
N=198
*= p<.05, **=p<.01 ***=p<.001

model indicated that the model accounted for approximately 13.6% of the variance in Creativity and Innovation scores.

Communication and Collaboration.

In the Elementary School analyses, Race, SES, Sex, and Collaborative learning were found to be significant predictors of students' Communication and Collaboration score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .144 standard deviations higher than non-white students and that higher SES students' scores were .186 standard deviations higher than lower SES students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their Communication and Collaboration scores decreased by .154 standard deviations. The R^2 for the model indicated that the model accounted for approximately 11.9% of the variance in students' Communication and Collaboration scores.

In the Middle School analyses, only SES was found to be significant predictors of students' Communication and Collaboration scores. Specifically, higher SES students scored .283 standard deviation units higher than lower SES students. The R^2 for the model indicated that the model accounted for approximately 11.8% of the variance in students' Communication and Collaboration scores.

Research and Information Fluency.

In the Elementary School analyses, Race, SES, and Collaborative learning were found to be significant predictors of students' Research and Information Fluency score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .130 standard deviations higher than non-white students and that higher SES students' scores were .221 standard deviations higher than lower SES students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their Research and Information Fluency scores decreased by .192 standard deviations. The R^2 for the model indicated that the model accounted for approximately 13.3% of the variance in students' Research and Information Fluency scores.

In the Middle School analyses, only Race and SES were found to be significant predictors of students' Research and Information Fluency scores. Specifically, white students scored .179 standard deviations higher than non-white students and higher SES students scored .188 standard deviation units higher than lower SES students. The R^2 for the model indicated that the model accounted for approximately 13.3% of the variance in students' Research and Information Fluency scores.

Critical Thinking, Problem Solving, and Decision Making.

In the Elementary School analyses, Race, SES, and Collaborative learning were found to be significant predictors of students' Critical Thinking, Problem Solving, and Decision Making score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .242 standard deviations higher than non-white students and that higher SES students' scores were .154 standard deviations higher than lower SES students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their Critical Thinking, Problem Solving, and Decision Making scores decreased by .146 standard deviations. The R^2 for the model indicated that the model accounted for approximately 14.2% of the variance in students' Critical Thinking, Problem Solving, and Decision Making scores.

In the Middle School analyses, only Race and SES were found to be significant predictors of students' Critical Thinking, Problem Solving, and Decision Making scores. Specifically, white students scored .215 standard deviations higher than non-white students and higher SES students scored .152 standard deviation units higher than lower SES students. The R^2 for the model indicated that the model accounted for approximately 12.4% of the variance in students' Critical Thinking, Problem Solving, and Decision Making scores.

Digital Citizenship.

In the Elementary School analyses, Race, SES, and Collaborative learning were found to be significant predictors of students' Digital Citizenship score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .184 standard deviations higher than non-white students and that higher SES students' scores were .108 standard deviations higher than lower SES students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their Digital Citizenship scores decreased by .149 standard deviations. The R^2 for the model indicated that the model accounted for approximately 10.4% of the variance in students' Digital Citizenship scores.

In the Middle School analyses, only SES was found to be significant predictors of students' Digital Citizenship scores. Specifically, higher SES students scored .278 standard deviation units higher than lower SES students. The R^2 for the model indicated that the model accounted for approximately 13.2% of the variance in students' Digital Citizenship scores.

Technology Operations and Concepts.

In the Elementary School analyses, Race, SES, Sex, Collaborative learning, and Computer Use were found to be significant predictors of students' Technology Operations and Concepts score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .156 standard deviations higher than non-white students, higher SES students' scores were .128 standard deviations higher than lower SES students' scores, and female students' scores were .094 standard deviations higher than male students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their Technology Operations and Concepts scores decreased by .145 standard deviations. Interestingly, the analyses also found that for every standard deviation increase in students' reports of their frequency of computer use in the classroom their Technology Operations and Concepts Score decreased by .260 standard deviation units. The R^2 for the model indicated that the model accounted for approximately 17.3% of the variance in students' Technology Operations and Concepts scores.

In the Middle School analyses, only Race and SES were found to be significant predictors of students' Technology Operations and Concepts scores. Specifically, white students scored .162 standard deviations higher than non-white students and higher SES students scored .244 standard deviation units higher than lower SES students. The R^2 for the model indicated that the model accounted for approximately 12.7% of the variance in students' Technology Operations and Concepts scores.

Overall Score.

In the Elementary School analyses, Race, SES, and Collaborative learning were found to be significant predictors of students' overall score on the 21st Century Skill Assessment. Analyses indicated that white students' scores were approximately .206 standard deviations higher than non-white students and that higher SES students' scores were .197 standard deviations higher than lower SES students' scores. Additionally, it was found that for every standard deviation increase in students' reports of their teachers' use of collaborative learning strategies their overall scores decreased by .181 standard deviations. The R^2 for the model indicated that the model accounted for approximately 16.0% of the variance in overall scores.

In the Middle School analyses, only Race and SES were found to be significant predictors of students' overall scores. Specifically, white students scored .181 standard deviations higher than non-white students and higher SES students scored .277 standard deviation units higher than lower SES students. The R^2 for the model indicated that the model accounted for approximately 17.2% of the variance in students' overall scores.

CHAPTER 4

DISCUSSION

As 1:1 computer initiatives become increasingly popular across the United States and internationally, it becomes increasingly important for researchers and policy advocates to understand the impacts of teaching with technology on students' engagement with school, academic achievement, and development of 21st century skills. The current study was undertaken in order to provide more information regarding the impact of teachers' technology-supported teaching strategies on all of these outcomes.

Study 1 examined the relationship between teachers' technology-supported teaching strategies and students' school satisfaction as well as academic outcomes. Multi-level analyses examining students' school satisfaction found that students' perceptions of teachers' use of personalized and authentic learning strategies had a significantly positive relationship with students' school satisfaction, even after controlling for demographic variables. Consistent with previous studies (Goldbeck et al. 2007; Suldo & Huebner, 2004), the current analyses also found that students' school satisfaction decreases significantly as students get older and that girls have significantly higher school satisfaction than boys. They also indicated that higher-SES students had higher levels of school satisfaction than lower-SES students. Interestingly, students' reports of the their teachers' use of collaborative learning strategies indicated that the more their teachers engaged in these strategies, the lower their school satisfaction, although it should be noted that this effect was significantly smaller than the positive impacts of using personalized and authentic learning strategies. There are several possible reasons for this effect. For instance, as reported in Storz, Hoffman, and Carroll (2013), when given computing devices, one of the first instructional strategies many teachers turn to is to assign more group projects. It could be that students in the current sample did not enjoy doing group projects or did not like other aspects of the teachers' teaching style that may have highly correlated with assigning more group projects. For instance, it may be that stronger teachers engaged in more creative lesson planning whereas weaker teachers simply assigned more group projects. As discussed above, delivering quality collaborative learning can be a difficult undertaking. However, this study was not able to link students directly to their teachers nor was it able to include measures of teacher quality, therefore the possible reasons here can only be speculated upon.

However, these results do support the idea that engaging students in personalized and authentic learning experiences positively impacts their school satisfaction. While many previous studies (e.g. Storz, Hoffman, & Carroll, 2013; Gulek & Demirtas, 2005; Silvernail & Lane, 2004; Lowther et al., 2005; etc.) have reported improvements in student engagement following the implementation of 1:1 initiatives, this is the first study to demonstrate the relationship between individual teaching-related mechanisms and levels of students' school satisfaction. The analyses indicate that these types of teaching strategies have a significant positive relationship with students' school satisfaction and therefore using these types of strategies may have impacts reaching beyond students' individual academic achievement. As mentioned above, school satisfaction is related to a large variety of both positive and negative student outcomes. Therefore, increasing students' school satisfaction may be a way to keep students' better engaged in the schooling process, making them more likely to work harder during school and more likely to complete high school.

The analyses also examined school-wide variables such as the overall level of teachers' technology-supported teaching strategies (as reported by both teachers and students) as well as school-level implementation factors. However, none of these school-level factors were significant after controlling for the more proximal factors at the individual-student level. This, unsurprisingly, indicates that students' school satisfaction is more likely to be influenced by factors that directly impact them (such as the teaching methods used by their own teachers) than by higher-level factors throughout the school. Although not undertaken in this study, it would be interesting to see in future analyses the extent to which these school-level factors impact the overall levels of students' school satisfaction within schools as a group, when the impacts of individual teachers are taken out. It is still possible that schools with higher levels of these practices as a whole may positively impact school-wide school satisfaction.

In addition to students' school satisfaction, the current study also investigated the relationship between teachers' technology-supported teaching strategies and changes in students' English-Language Arts (ELA) achievement scores. It is important to note here that the current analyses examined the change in students' test scores between fall and spring assessments, therefore capturing the changes in achievement attributable to that one year in school. The analyses revealed that over the course of the year, white students' achievement grew significantly more than non-white students, special education students' achievement grew significantly less than non-special education students, and higher-SES students' achievement grew more than lower-SES students' achievement. These findings are altogether unsurprising given the extensive work in the field highlighting the persistent underachievement of low income and minority students in the United States as well as students in special education. However, there was a significant positive effect for teachers' authentic learning strategies. This indicates that the more teachers used authentic learning strategies with their students, the more the students' achievement in ELA increased. This finding supports other positive impacts of technology use on students' ELA scores (e.g., Gulek & Demirtas, 2005; Sclater et al., 2006; Bebell & Kay, 2010; and Shapley et al., 2010). However, this study takes these findings one step farther as the current study examined the *changes* in student test scores rather than examining their scores at only one point in time. Thus, while other studies have demonstrated a relationship between increased technology use and higher test scores, the current study demonstrates a more direct relationship between teachers' use of technology-supported authentic learning strategies and *increases* in students' achievement over the course of the year they were exposed to such teaching strategies. Therefore the current study provides the most direct evidence to date of the positive relationship between such teaching strategies within a 1:1 environment and students' ELA achievement.

Similar to the findings described above concerning the null findings of school-level factors on students' school satisfaction, the same null finding was found for students' ELA achievement scores. Once again, this could be the result of students' being more influenced by more proximal factors and further study may be warranted to investigate these effects on school-wide results.

In addition to students' ELA achievement scores, the relationship between technology-supported teaching strategies and students' mathematics scores was also investigated. The results indicated similar relationships between race, SES, and special education status on academic gains in mathematics as on their ELA achievement scores, but also indicated that boys tended to have greater gains than girls over the course of the year. While this result is slightly surprising given the recent work on gender differences between boys and girls (Spelke, 2005), it should be noted that this result is not from a nationally representative sample and therefore these differences may be the result of some kind of local phenomenon. However, while this result may be worthy of further study, it is not of particular interest within the current study.

Similar to the results obtained for students' changes in their ELA scores, teachers' use of authentic learning strategies were also found to significantly and positively relate to changes in students' mathematics scores. Interestingly, higher levels of students' computer use as also found to have a significant positive relationship with students' changes in mathematics achievement. This is particularly interesting given previous findings by several researchers that computer use was often found to be lowest in mathematics classes (Holcomb, 2009; Zucker & McGhee, 2005; Silvernail & Lane, 2004; Lowther et al., 2005). This finding indicates that while computer use may be lowest among mathematics classes, this may be the area in which they have an even greater impact. This would be consistent with other studies which found a significant, positive relationship between access and use of computing devices and students' state standardized math scores (Muir, 2005; Stevenson, 1998; eMINTS National Center, 2004; eMINTS National Center, 2007; Shapley et al., 2010). However, results also indicated that teachers' use of collaborative learning strategies in math had a significant negative relationship with changes in students' mathematics test scores. As discussed above, there are several possible explanations for why teachers' use of certain collaborative learning strategies may have a negative relationship with student outcomes. In mathematics it may also be the case that group projects related to math may not be the best strategy for increasing students' understanding of the material. Unlike in reading and writing, where student-to-student feedback can be a significant part of developing higher-level skills such as creativity, mathematics may be an area where students may need more individualized practice when engaging in mathematical problem solving and computation. This finding also highlights one of the benefits of the current study, namely that because it has examined each of these technology-supported teaching strategies separately, it has been able to parse the relationships of the different teaching strategies across two major areas of academic achievement. It may be that although each of these practices has been hypothesized to relate to increased student achievement, different practices may have different impacts based on the subject area. By examining each of these practices separately on each academic area, this study supports a more nuanced approach to using these pedagogical strategies within different academic areas.

Also different from previous analyses, mathematics was the only area in which school-level factors significantly related to changes in student outcomes. Notably, school-wide levels of teachers' use of authentic learning strategies (as reported by students) was positively and significantly related to positive changes in students' mathematics scores. This indicates that school-wide levels of authentic teaching strategies in mathematics had a positive relationship with students' scores above and beyond the relationships between the strategies used by individual teachers. This may indicate that students in schools where mathematics teachers collaborated in their use of authentic learning strategies in math had greater mathematics achievement gains than students in schools where this was not as prevalent. However, there was also a significant negative relationship between school-wide levels of personalized learning (as reported by students) and students' changes in mathematics achievement. This may indicate that students in schools where more teachers try to personalize learning may not learn as much as students at schools where this is not as much of a common practice. While personalizing learning can be an important strategy in raising student achievement, this finding may highlight the dangers of personalizing learning too much. It may be that in schools where this is more common, teachers are personalizing their lessons in such a way as to underestimate the abilities of some of their students. There has been considerable literature on issues such as student tracking, with several studies finding that inflexible tracking systems can have negative effects on student performance (Gamoran, 1992). While this study did not examine these impacts, it could be that schools that engage in more personalization of learning may be underestimating students' abilities in mathematics and therefore not hold them to the same higher standard as schools who engage in less. However, as stated previously, this is only one of many possible hypotheses and future investigation may be warranted to explain this effect.

Another interesting school-level finding was that school-wide levels of quality professional development was also found to positively relate to changes in students' mathematics achievement scores. This may indicate that quality professional development related to the implementation of a 1:1 technology initiative may have the greatest immediate impact on changes in students' mathematics scores. This supports the idea that quality professional development related to teaching with technology may be most immediately beneficial for mathematics teachers. As reported earlier, mathematics was the area least likely to use technology in other 1:1 technology initiatives. These results suggest that higher quality professional development may significantly impact teachers' abilities to properly utilize the technology within their classrooms, leading to increases in both computer use and authentic learning experiences and therefore having a positive impact on students' mathematics achievement. Additionally, this finding builds upon previous work by Shapley et al. (2010) that posited the need to examine implementation factors when researching the impacts of 1:1 technology initiatives on student outcomes.

Overall, the results of Study 1 demonstrate significant, positive effects for the use of personalized and authentic learning strategies on students' school satisfaction, authentic learning strategies on changes in students' ELA achievement, and authentic learning and computer use on changes in mathematics achievement. However, the study also demonstrated some negative relationships surrounding the use of collaborative learning strategies and changes in mathematics achievement and in school satisfaction. Taken together, these findings support the overall positive relationship between technology-supported teaching strategies and student outcomes, but highlight the importance of examining the effects of 1:1 technology initiatives in a nuanced way that parses out the impacts based on teacher practices. By examining the effects of different teacher practices, researchers may be able to build a more solid and nuanced view of which strategies may be best in which subjects rather than simply positing that all practices will produce benefits in all settings. This is one way in which the current research furthers the study of 1:1 technology initiatives in school settings.

Study 2 examined the relationship of teachers' technology-supported teaching strategies on students' 21st century learning outcomes among a sample of 5th grade and a sample of 8th grade students. Similar to the academic outcomes described above, white students consistently scored higher than non-white students in most domains across both samples and higher-SES students scored higher than lower-SES students across every domain in both samples. As this test contained many academic components, such as being able to read and follow the directions and problem solve, these findings are unsurprising. What was more surprising was that students' reports of their teachers' use of collaborative learning strategies was significantly negatively associated with students' 21st century learning outcomes across all six domains as well as their overall score in the elementary sample only. This is consistent with some of the previous results in Study 1 which found collaborative learning to be negatively related to several outcomes. However, this finding was inconsistent between the two samples (5th grade and 8th grade). This may indicate that collaborative learning may be associated with negative outcomes only at younger grade levels (something not teased apart in the findings from Study 1). This may be because students in younger grades are still in the process of building foundational skills and therefore benefit more from more individualized work than from group work. It may be that collaborative learning strategies may be more beneficial for students who have already cemented their basic skills and are focusing on more high-level concepts. For instance, although collaborative learning tended to have a negative impact (although non-significant) across most domains of 21st century learning in the 8th

grade sample, it trended positively (although again non-significantly) in the area of Technology Operations and Concepts. Therefore, future work may try to focus on the possible differential effects of collaborative learning on building foundational skills vs. higher-order skills or on skills such as technology use.

As the push for more technology in schools continues to grow, there is still much more work that should be undertaken by researchers to determine how this technology may best be used to improve student outcomes. While this study has added interesting new information to this field, there are several limitations inherent to the study and many ways in which to follow up this research. One significant limitation is that this study focused solely on one school district implementing a 1:1 initiative. Further research should attempt to study several different school districts and their various methods of implementation in order to gain a better understanding of the variability in 1:1 technology integration and the strategies used by teachers to incorporate technology into their classrooms. This, and further, studies may also benefit from being able to directly link students to their teachers. Due to limitations placed by the district, this study was not able to directly link individual teachers to their students to examine how teacher factors related to technology integration directly impact student performance, but rather relied on students' reports of their teachers' behaviors. Further research may benefit from being able to more precisely link teachers' teaching strategies and attitudes regarding technology use to student outcomes. For instance, a recent paper by Lamont et al. (in press) used latent class analysis to deduce the characteristics of five distinct groups of teachers based on their use of teaching strategies related to the adoption of a 1:1 technology initiative. In future research it may be fruitful for researchers to adopt such an approach and, by linking teachers to students, determine if and how membership in one of these classes impacts student outcomes. Such an analysis would provide fruitful information and help to disentangle the potential effects of technology use based on types of technology integration. Certainly as an increasing number of states and local districts pour money into 1:1 technology initiatives, it will be important for researchers to have a more sound and nuanced understanding of the impacts of such programs on student outcomes.

REFERENCES

Baker, J.A. (1998). The social context of school satisfaction among urban, low-income, African-American students. *School Psychology Quarterly, 13,* 25-44.

Baker, J.A., Dilly, L. Aupperless, J., & Patil, S. (2003). The developmental context of school satisfaction: Schools as psychologically healthy environments. *School Psychology Quarterly*, *18*, 206-222.

Bebell, D., & Kay, R. (2010). One to one computing: A summary of the quantitative results from the Berkshire wireless learning initiative. *The Journal of Technology, Learning and Assessment*, *9*(2). Retrieved from http://napoleon.bc.edu/ojs/index.php/jtla/article/view/1607

Benbunan-Fich, R., Hiltz, S. R., & Turoff, M. (2003). A comparative content analysis of face-to-face vs. asynchronous group decision making. Decision Support Systems, 34(4), 457–469.

Blumenfeld, P.C., Marx, R.W., Soloway, E., & Krajcik, J. (1996). Learning with peers: From small group cooperation to collaborative communities. *Educational Researcher*, 25 (8), 43-46.

Brett, C. (2004). Off-line factors contributing to online engagement. *Technology, Pedagogy and Education*, *13*(1), 83-95.

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1985). Mathematics in the streets and in schools. *British journal of developmental psychology*, *3*(1), 21-29.

Carpenter, T. P., Dossey, J. A., & Koehler, J. L. (2004). Classics in mathematics education research. *AMC*, *10*, 12.

Clements, M. (2004). Perspective on “mathematics in the streets and in schools”. In Carpenter, T. P., Dossey, J. A., & Koehler, J. L. (Eds.), *Classics in mathematics education research* (186). National Council of Teachers of Mathematics.

Collins, A. (1988). Cognitive Apprenticeship and Instructional technology. (Technical Report No. 6899). BBN Labs Inc., Cambridge, MA.

Collins, A. & Halverson, R. (2009). *Rethinking education in the age of technology: The digital revolution and schooling in America*. New York, NY: Teachers College Press.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA: Harvard University.

Cuban, L. (2006, October 18). Commentary: The laptop revolution has no clothes. *Education Week*, p. 29.

DeSantis-King, A.L., Huebner, S., Suldo, S.M., & Valois, R.F. (2006). An ecological view of school satisfaction in adolescence: Linkages between social support and behavior problems. *Applied Research in Quality of Life*, *1*, 279–295.

Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, *95*, 542-575.

Dillenbourg, P. (1999). What do you mean by "collaborative learning"? In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1-16). Amsterdam, NL: Pergamon, Elsevier Science.

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

Eamon, M.K. (2002). Influences and mediators of the effect of poverty on young adolescent depressive symptoms. *Journal of Youth & Adolescence, 31*, 231–242.

Ekstrom, R.B., Goertz, M.E., Pollack, J.M., & Rock, D.A. (1986). Who drops out of high school and why? Findings from a national survey. *Teachers College Record, 87*, 357–373.

Elmore, G.M., & Huebner, E. (2010). Adolescents' satisfaction with school experiences: Relationships with demographics, attachment relationships, and school engagement behavior. *Psychology in the Schools, 47*, 525-537.

eMINTS National Center. (2004). *Analysis of 2003 MAP results for eMINTS students*. Retrieved from http://www. emints.org/evaluation/reports/map2003.pdf

eMINTS National Center. (2007). *Analysis of 2005 MAP results for eMINTS students.* Retrieved from http://www. emints.org/evaluation/reports/map2005.pdf

Epstein, J. (1981). Patterns of classroom participation, student attributes, and achievements. In J. Epstein (Ed.), *Quality of school life* (pp. 81–116). Lexington, MA: Heath.

Epstein, J. & McPartland, J.M. (1976). The concept and measurement of the quality of school life. *American Educational Research Journal*, 13, 15-30.

Fisch, K., & McLeod, S. (2009). Did You Know? 3.0 – 2009 Edition. Gevonden op 15-5-2009 op www.youtube.com/watch?v=PHmwZ96_Gos

Fjermestad, J. (2004). An analysis of communication mode in group support systems research. *Decision Support Systems*, 37(2), 239–263.

Fleischer, H. (2012). What is our current understanding of one-to-one computer projects: A systematic narrative research review. *Educational Research Review, 7*(2), 107–122. doi:10.1016/j.edurev.2011.11.004

Fletcher-Flinn, C.M., & Gravatt, B. (1995). The efficacy of computer assisted instruction (CAI): A meta-analysis. *Journal of Educational Computing Research, 12*(3), 219–242.

Furrer, C., & Skinner, E. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology, 95,* 148–162.

Gamoran, A. (1992). The variable effects of high school tracking. *American Sociological Review*, 812-828.

GeorgiaNETS - K-8 Scope and Sequence. (2013). Retrieved September 27, 2014, from http://georgianets.wikispaces.com/K-8+Scope+and+Sequence.

Gilman, R., Huebner, E.S., Laughlin, J.E. (2000). A first study of the multidimensional students' life satisfaction scale with adolescents. *Social Indicators Research*, 52, 135-160.

Goldbeck, L. Schmitz, T. G., Besier, T.G., Herschback, P., & Henrich, G. (2007). Life satisfaction decreases during adolescence. *Quality of Life Research, 16,* 969-979.

Goldberg, A., Russell, M., & Cook, A. (2003). The effect of computers on student writing: A meta-analysis of studies from 1992 to 2002. *Journal of Technology, Learning, and Assessment, 2*(1). Available from http://www/jtla.org

Goodenow, C., & Grady, K.E. (1992). The relationship of school belonging and friends' values to academic motivation among urban adolescent students. *Journal of Experimental Education, 62,* 60–71.

Grimes, D., & Warschauer, M. (2008). Learning with Laptops: A Multi-Method Case Study. *Journal of Educational Computing Research*, *38*(3), 305–332. doi:10.2190/EC.38.3.d

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

Hall, T. (2002). *Differentiated instruction.* Wakefield, MA: National Center on Accessing the General Curriculum. Retrieved from http://www.cast.org/publications/ncac/ncac_diffinstruc.html

Herrington, J. & Kervin, L. (2007). *Authentic Learning Supported by Technology: Ten suggestions and cases of integration in classrooms,* Educational Media International, 44:3, 219-236.

Herrington, J., & Oliver, R. (2000). An instructional design framework for authentic learning environments. *Educational technology research and development*, *48*(3), 23-48.

Hilbert, M. (2012). How much information is there in the "information society"?. *Significance*, *9*(4), 8-12.

Holcomb, L. B. (2009). Results & lessons learned from1: 1 laptop initiatives: A collective review. *TechTrends: Linking Research & Practice to Improve Learning*, *53*(6), 49–55.

Hu, W. (2007, May 4). Seeing no progress, some schools drop laptops. *NewYorkTimes.com*. Retrieved from http://www.nytimes.com/2007/05/04/education/04laptop.html.

Huebner, E.S. (1994). Preliminary development and validation of a multidimensional life satisfaction scale for children. *Psychological Assessment, 6*, 149–158.

Huebner, E.S., & Gilman, R. (2006). Students who like and dislike school. *Applied Research in Quality of Life, 2,* 139 – 150.

Huebner, E. S., Laughlin, J. E., Ash, C., & Gilman, R. (1998). Further validation of the Multidimensional Students' Life Satisfaction Scale. *Journal of Psychological Assessment*, *16*, 118-134.

Huebner, E.S., Valois, R. F., Paxton, R. J., & Drane, J. W. (2005). Middle school students' perceptions of quality of life. *Journal of Happiness Studies, 6*, 15–24.

Intel Inc. (2008). Technology as a tool for sys- tem-wide transformation: *The 21st century learning initiative at Auburn City Schools*. Retrieved from http://www. k12blueprint.com/k12/blueprint/story_ 1on1_in_auburn_alabama.php

ISTE Standards For Students. (2014). Retrieved from https://www.iste.org/standards/standards-for-students.

Jeroski, S. (2003). *Wireless writing project*. Research report: Phase II. Retrieved from http://142.27.144.130/documents/WWP/FSJ_WWP_Report03.pdf.

Johnson, D. W., & Johnson, R. (1989). *Cooperation and competition: Theory and research*. Edina, MN: Interaction.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Cooperative learning returns to college: What evidence is there that it works? *Change,* 30(4), 26–35.

Johnson, D. W., Johnson, R., Stanne, M., & Garibaldi, A. (1990). The impact of group processing on achievement in cooperative groups. *Journal of Social Psychology*, 130, 507–516.

Johnson, R., Johnson, D. W., Stanne, M., Smizak, B., & Avon, J. (1987). Effect of composition pairs at the word processor on quality of writing and ability to use the word processor. Minneapolis: Cooperative Learning Center, University of Minnesota.

Keengwe, J., Schnellert, G., & Mills, C. (2012). Laptop initiative: Impact on instructional technology integration and student learning. *Education and Information Technologies*, *17*(2), 137-146.

Keys, W., & Fernandes, C. (1993). *What do students think about school? A report for the National Commission on Education*. Berkshire, UK: National Foundation for Educational Research.

Kulik, J.A. (1994). Meta-analytic studies of findings on computer-based instruction. In E. L. Baker & H. F. O'Neil, Jr. (Eds.), *Technology assessment in education and training* (pp. 9–33). Hillsdale, NJ: Lawrence Erlbaum Associates.

Ladd, G.W., Buhs, E. S., & Seid, M. (2000). Children's initial sentiments about kindergarten: is school liking an antecedent of early classroom participation and achievement? *Merrill-Palmer Quarterly, 46*(2), 255-279.

Lamont, A.E., Markle, R.S., Wright, A.W., Abraczinskas, M., Siddall, J., Wandersman, A., Imm, P., Skiles, B. (in press). Innovative methods in evaluation: An application of Latent Class Analysis to assess how teachers adopt educational innovations.

Lee, Y.-H., Waxman, H., Wu, J.-Y., Michko, G., & Lin, G. (2013). Revisit the Effect of Teaching and Learning with Technology. *Educational Technology & Society*, *16*(1), 133–146.

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

Levy, F., & Mundane, R.J. (2004). The new division of labor. *How computers are changing the way we work*. Princeton University Press and the Russell Sage Foundation.

Li, Q., & Ma, X. (2010). A Meta-analysis of the Effects of Computer Technology on School Students' Mathematics Learning. *Educational Psychology Review*, *22*(3), 215–243. doi:10.1007/s10648-010-9125-8

Locke, T., & Newcomb, M. (2004). Adolescent predictors of young adult and adult alcohol involvement and dysphoria in a prospective community sample of women. *Prevention Science*, *5*(3), 151-168.

Lowther, D. L., Ross, S. M., Strahl, J. D., Inan, F. A., & Pollard, D. (2005). Freedom to learn program: Michigan 2004-05 evaluation report.

Lowther, D. L., Ross, S. M., & Morrison, G. M. (2003). When each one has one. *Educational Technology Research and Development*, *51*(3), 23-44.

Maton, K. (1990). Meaningful involvement in instrumental activity and well-being: Studies of older adolescents and at risk teenagers. *American Journal of Community Psychology*, *18*, 297-320.

McFarlane, A. E., Friedler, Y., Warwick, P., & Chaplain, R. (1995). Developing an understanding of the meaning of line graphs in primary science investigations, using portable computers and data logging software. *Journal of Computers in Mathematics and Science Teaching*, *14*, 461-480.

McNabb, M., Hawkes, M., & Rouk, U. (1999). Critical Issues in Evaluating the Effectiveness of Technology.

Moran, J., Ferdig, R., Pearson, P. D., Wardrop, J., & Blomeyer, R. (2008). Technology and Reading Performance in the Middle-School Grades: A Meta-Analysis with Recommendations for Policy and Practice. *Journal of Literacy Research*, *40*(1), 6–58. doi:10.1080/10862960802070483

Muir, M. (2005). A Model for Evaluating 1-to-1 Learning with Laptop Initiatives. Retrieved from http://www.mcmel.org/ MLLS/eval/model.html

Newcomb, M., Bentler, P., & Fahy, B. (1987). Cocaine use and psychopathology: Associations among young adults. *International Journal of the Addictions*, *22*(12), 1167-1188.

O'Dwyer, L., Russell, M., Bebell, D., & Tucker-Seeley, K. R. (2005). Examining the relationship between home and school computer use and students' English/language arts test scores. *The Journal of Technology, Learning and Assessment*, *3*(3).

O'Dwyer, L., Russell, M., Bebell, D., & Tucker-Seeley, K. R. (2008). Examining the relationship between students' mathematics test scores and computer use at home and at school. *The Journal of Technology, Learning and Assessment*, *6*(5). Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/article/view/1635

Oakley, A., Biannen, J., & Dodd, K. (1992). Schools and smoking: School features an variations in cigarette smoking by children and teachers. *British Journal of Educational Psychology, 55,* 34-44.

Okun, M.A., Kardash, C.A., & Janiga, J.M. (1986). Age differences in college values and perceived quality of college life. *Educational Gerontology*, *12,* 409–416.

Oliver, K. M., & Corn, J. O. (2008). Student-reported differences in technology use and skills after the implementation of one-to-one computing. Educational Media International, 45(3), 215–229.

Patrick, S., Kennedy, K., & Powell, A. (2013). Mean what you say: defining and integrating personalized, blended and competency education. iNACOL. Retrieved from http://www.inacol.org/cms/wp-content/uploads/2013/10/iNACOL-Mean-What-You-Say-October-2013.pdf.

Ramires, M., & Althouse, P. (1995). Fresh thinking: GIS in environmental education. THE Journal, 23 (2), 87-90.

Resnick, L. B. (1987). The 1987 presidential address: Learning in school and out. *Educational Researcher*, 13–54.

Resta, P., & Laferrière, T. (2007). Technology in Support of Collaborative Learning. *Educational Psychology Review*, *19*(1), 65–83.

Roschelle, J., Penuel, W. R., & Abrahamson, L. (2004). The networked classroom. *Educational Leadership*, *61*(5), 50-54.

Russell, M. (1999). Testing on Computers: A Follow-up Study Comparing Performance on Computer and On Paper. *Education Policy Analysis Archives*. Received on October 2, 2002 at: http://epaa.asu.edu/epaa/ v7n20

Russell, M. (2000). *It's time to upgrade: Tests and administration procedures for the new millennium*. ERIC Clearinghouse. Retrieved from http://www.usca.edu/Essays/vol12002/time_to_upgrade_revised.pdf

Russell, M. & Haney, W. (1997). Testing Writing on Computers: An Experiment Comparing Student Performance on Tests Conducted via Computer and via Paper-and–Pencil. *Education Policy Analysis Archives.* Received on April 2003 at: http://olam.ed.asu.edu/epaa/v5n3.html

Russell, M. & Plati, T. (2001). Mode of administration effects on MCAS composition performance for grades eight and ten. *Teachers College Record*. Retrieved February 1, 2003 from http://www.tcrecord.org/ Content.asp?ContentID=10709.

Sclater, J., Sicoly, F., Abrami, P., & Wade, C. A. (2006). Ubiquitous technology integration in Canadian public schools: Year one study. *Canadian Journal of Learning and Technology/La Revue Canadienne de L'apprentissage et* de La *Technologie, 32*(1). Retrieved from http://www.cjlt.ca/index.php/cjlt/article/viewArticle/80

Seligson, J.L., Huebner, E.S & Valois, R.F. (2003). Preliminary validation of the Brief Multidimensional Students' Life Satisfaction Scale (BMSLSS). *Social Indicators Research, 61*, 121-145.

Shapley, K. S., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *The Journal of Technology, Learning and Assessment*, *9*(4). Retrieved from https://ejournals.bc.edu/ojs/index.php/jtla/article/view/1609

Siddall, J., Huebner, E. S., & Jiang, X. (2013). A prospective study of differential sources of school-related social support and adolescent global life satisfaction. *American Journal of Orthopsychiatry*, *83*(1), 107.

Silvernail, D. L., & Gritter, A. K. (2007). *Maine's middle school laptop program: Creating better writers*. Gorham, ME: Maine Education Policy Research Institute. Retrieved from http://www.sjchsdow.catholic.edu.au/documents/research_brief.pdf

Silvernail, D. L., & Lane, D. M. (2004). The impact of Maine's one-to-one laptop program on middle school teachers and students. *Maine Education Policy Research Institute (MEPRI), University of Southern Maine*. Retrieved from https://wiki.rockwallisd.org/sandbox/groups/technologysptools/wiki/fb328/attachments/c39b3/Maine%20Research.pdf

South Carolina Department of Education. (2016). Active Student Headcounts. Retrieved from: http://ed.sc.gov/data/other/student-counts/active-student-headcounts/

Spelke, E. S. (2005). Sex differences in intrinsic aptitude for mathematics and science?: a critical review. *American Psychologist*, *60*(9), 950.

Springer, L., Stanne, M., & Donovan, S. (1998). Effects of cooperative learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. Review of Educational Research, 69(1), 21–51.

Stahl, G. (2004). Building collaborative knowing: Elements of a social theory of CSCL. In J.-W. Strijbos, P. Kirschner, & R. Martens (Eds.), What we know about CSCL: And implementing it in higher education (pp. 53–86). Boston, MA: Kluwer.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. *Cambridge Handbook of the Learning Sciences, 2006*. Retrieved from http://gerrystahl.net/cscl/CSCL_English.htm

Strivastava, R. & Strivastava, B. (1986). Punctuality and life satisfaction among tranquiliser users. *Indian Psychology Review, 30(3),* 36-38.

Stevenson, K. R. (1998). *Evaluation report - year 2: Schoolbook laptop project (No. 2).Beaufort: University of South Carolina Department of Educational Leadership and Policies*. Retrieved July 10, 2008, from http://www.beaufort.k12.sc.us/district/ ltopeval.html

Storz, M. G., & Hoffman, A. R. (2013). Examining Response to a One-to-One Computer Initiative: Student and Teacher Voices. *RMLE Online: Research in Middle Level Education*, *36*(6), n6.

Suldo, S. M., & Huebner, E. S. (2004). The role of life satisfaction in the relationship between authoritative parenting dimensions and adolescent problem behavior. *Social Indicators Research*, *66*, 165–195.

Technology Integration Matrix. (2011). Retrieved September 27, 2014, from http://fcit.usf.edu/matrix/index.php

Voogt, J.M., & Odenthal L.E. (1997). Emergent practices geportretteerd. Conceptueel raamwerk. Enschede: Universiteit Twente.

Voogt, J., & Roblin, N. P. (2010). 21st century skills. *Discussienota. Zoetermeer: The Netherlands: Kennisnet*.

Vygotsky, L. S. (1978). Mind in society: the development of higher psychological processes. Cambridge, MA: Harvard University Press.

Warschauer, M. (2007). Information literacy in the laptop classroom. Teachers College Record, 109(11), 2511–2540.

Waxman, H. C., Lin, M. F., & Michko, G. (2003). *A meta-analysis of the effectiveness of teaching and learning with technology on student outcomes*. Learning Point Associates.

Weston, M. E., & Bain, A. (2010). The end of techno-critique: The naked truth about 1: 1 laptop initiatives and educational change. *The Journal of Technology, Learning and Assessment, 9*(6). Retrieved from https://ejournals.bc.edu/ojs/index.php/jtla/article/view/1611

Wehlage, G.G., Rutter, R.A., Smith, G.A., Lesko, N., & Fernandez, R.R. (1989). *Reducing the risk: Schools as communities of support*. New York, NY: Falmer Press.

Wong, M. & Csikzentmihaly, M. (1991). Motivation and academic achievement: The effects of personal traits and quality of experience. *Journal of Personality, 59*, 537-574.

Zheng, B, Warschauer M., & Farkas, G. (2013). Digital writing and diversity: the effects of school laptop programs on literacy processes and outcomes. *Journal of Educational Computing Research*, 48(3), 267-299.

Zucker, A. A., & Hug, S. T. (2008). Teaching and learning physics in a 1:1 laptop school. *Journal of Science Education and Technology*, 17(6), 586–594.

Zucker, A., McGhee, R., Hall, C. Y., Hersh, L., Keefe, D., Kim, B., et al. (2005). *A study of one-to-one computer use in mathemat- ics and science instruction at the secondary level in Henrico County Public Schools.* Retrieved from http://ubiq-computing.org.