UNDERREPRESENTED MINORITY STUDENTS IN FOUR URBAN SCHOOL DISTRICTS: A STUDY OF TECHNOLOGY USE AND STUDENT ACADEMIC PERFORMANCE IN MATH GRADES FOUR AND EIGHT

by

Olivia Majesky Blackmon
A Dissertation
Submitted to the
Graduate Faculty
of
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in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Sociology

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DEDICATION

This is dedicated to my loving husband Bill, my five wonderful children Anna, Huit, Joseph, Abby and Amelia. It is also dedicated to my grandparents Joseph and Yolanda Gregorio who always believed in my dreams, taught me about hard work, self-respect and persistence to achieve my goals.

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ABSTRACT

UNDERREPRESENTED MINORITY STUDENTS IN URBAN SCHOOL DISTRICTS: A STUDY OF TECHNOLOGY USE AND STUDENT ACADEMIC PERFORMANCE IN MATH GRADES FOUR AND EIGHT

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Over the past two decades, access to technology at home and in schools has increased significantly. While nearly all children have access to technology, there continues to be an ongoing debate over the effective use of technology and its relationship to student achievement. Studies have demonstrated inconclusive results, with findings revealing both statistically significant positive and negative results between the use of technology and student achievement. Researchers believe that these debatable results are attributed to using basic regression models to examine the relationship between technology and student achievement in mathematics based on race/ethnicity, gender, or socio-economic status, while analysis should explore a multi-level approach due to the nested nature of student data (Wenglinsky, 2005 and Warschauer, 2011). Since students are organized at more than one level, and nested within the context of their environment, an Ordinary Least Squares (OLS) approach assessing different environmental contexts could

potentially lead to more conclusive and meaningful results. Thus, the purpose of the research study is to examine a multi-level approach using OLS to determine if technology access, frequency and usage have an impact on grade four and eight mathematics student achievement across four areas of investigation: home effects, overall-school effects, teacher effects, and student-reported classroom effects.

At the home-level, studies have repeatedly shown that software and hardware technology access and usage impacts student achievement in the classroom (Berliner, 2009 and Sirin, 2005). However, research studies have not focused on the role of subject specific (i.e. math) technology use at the home and math student achievement. At the school- and classroom-level, research has illustrated that access to technology can impact student achievement; however, little research has been conducted on the effectiveness of didactic (i.e. drill and practice) vs. constructivist (higher order thinking) technology approaches implemented within the classroom on math student achievement. Additionally, of particular interest are the roles that teachers' exposure to professional development in technology and specific uses of computer technology play in the relationship between student computer usage in the classroom and student achievement in mathematics.

In order to explore these multi-level relationships, this study utilizes restricted data from the U.S. Department of Education's National Assessment of Educational Progress (NAEP) to evaluate the impact of technology on math grade four and grade eight achievement in 2011. The research focuses on four urban school districts (Trial Urban District Assessment or TUDA) and compares that to large city, state-wide and nation-wide populations.

The research findings indicate that there are differences in both access and usage based on grade and school location. Overall access to a computer at home and in the classroom improved grade four and eight student scores, while usage types had mixed results. Further analysis reveals that most *student-reported* variables associated with computer technology usage in the home and in the classroom decrease achievement, while *teacher-reported* variables associated with in-classroom usage had mixed results. A closer examination into the types of technology used in grade four and grade eight reveal that specific applications can significantly impact mathematic achievement across the nation, while in specific urban areas the particular application has little to adverse effects.

CHAPTER ONE: INTRODUCTION

A fundamental goal of education is to ensure that students regardless of their demographic background have a chance to be successful both in school and throughout life. A person's primary and secondary educational experience and outcomes can influence whether they will enter and graduate college, what career choices they have, and their salaries. Education was supposed to serve the nation as "the great equalizer;" however, the pervasive inequality between low and high-income school districts is widely recognized by sociologists, educators, policy makers, and the public. Schools serving low-income students have many barriers such as a lack of resources or financial funding, difficulties attracting qualified teachers, less parental involvement, etc. Not only are students faced with low-quality schools, but they often enter into the education system already substantially behind their peers, and low-quality school systems can not support the needs of these children.

Many Americans believe that schools should provide an environment for children to have equal chances despite the advantages or disadvantages at home. Despite this near universal belief system, our school system often plays a leading role in supporting inequalities. For example, sociological research shows that math achievement gaps in standardized test scores are strongly associated with family background (i.e. race, ethnicity, and socio-economic-status). Research points to how the school structure supports inequalities, as social differences in achievement actually increase as a result of children's participation in differentiated educational experience as they move through the education system (Secada 1992; Wenglinsky 2004; Lee 2006; Ferguson 2007).

This study explores differences both at home and within schools in academic math competence among 4th and 8th grade students. This research specifically investigates the effects of access, frequency and use of educational-technology on student achievement and outcomes. Technology will be examined at four levels of student utilization: at home, overall-school access, teachers incorporation of technology into the curriculum, and the students' experience within the classroom. These indicators are markers of how technology access, frequency and usage can translate into mathematics skills and competencies on standardized exams. This assessment will hopefully provide some clarity on the success of technology to decrease the achievement gaps, despite racial and social-class disparities.

Background

Our education system is failing to support students, particularly many who attend disadvantaged school systems, as evidenced by the achievement gap between minority and white test scores on national and state standardized tests. As a nation, we must find a way to close the gap by raising the achievement of minorities in disadvantaged school systems to match that of white students.

Equity in education means that personal or social circumstances such as social-economic-status, ethnicity/race, gender and family background are not hurdles to achieving educational potential and that all students attain at least the basic minimum level of skills in order to be a productive member of society. The education system must provide the vast majority of students with equal opportunities to attain a proficient skill level in spite of their circumstances. Quality of education refers to an array of aspects, but for purposes of this dissertation the focus is on the quality of teachers' ability to use technology, their computer professional development, and the level of quality technology (access, frequency, and usage) in the math classrooms. A high-quality learning environment, may support students in disadvantaged and promote equality in achievement.

Understanding why our education system continues to lack in quality and equity, producing achievement gaps along race and class lines in America is central to producing effective educational policy interventions. Researchers focus on several explanations for why children in disadvantaged school districts are underperforming. First, schools in high-poverty areas, typically serving minorities, often lack resources and financial funding needed to improve the curriculum, teacher quality and technology programs. Second, independent of financial resources, schools lack the "capacity to substantially improve student learning" and have low-quality standard operating practices and a lack of "instructional capacity of staff" (Jacob and Ludwig 2009: 56). Third, broadly speaking - schools serving disadvantaged students (i.e. poor and minority) have fewer financial resources to invest back into the school, and thus have less flexibility to provide a positive solution to improve and update the classrooms instruction and curriculum materials (Buckendahl et al. 2009). Additionally, Jacob and Ludwig (2009) found that disadvantaged school districts do not have "key objectives and hold key actors accountable, and thus additional spending is squandered" instead of being utilized to provide sufficient resources for their students (Jacob and Ludwig 2009: 58). Lastly, social contexts outside of school such as the family, neighborhood and peer relationships provide a difficult environment for low-income children to take advantage of educational opportunities. These four complex and interacting explanations behind the achievement gaps, provide some reasons behind the disparities between groups of people.

Over the past forty years, research on educational improvement and equality suggests that "nothing works" for poor children, creating and contributing to a sense of pessimism about the capability of the U.S. educational system to improve the lives and life chances of disadvantaged children, and improve their life chances (Glazer 1986). Sociological research has examined the causes in these academic gaps, emphasizing that disadvantaged groups face more challenges external to schools and factors that are influenced by school-based conditions. In 1966, the Coleman Report found that outside-of-school factors, specifically peer-group effects, neighborhood and community issues, and home life styles had more influence on student achievement than within-school factors (Coleman 1966). This report cast doubt on the ability of schools to decrease achievement gaps on their own. Following this report, in the 1970s Samuel Bowels and Herbert Gintis' as well as Christopher Jencks concluded that schools reproduced inequalities or had little effect on them (Bowles and Gintis 1976; Jencks and Phillips 1998). These ideas continue to lead researchers, such as Jean Anyon (Anyon 2011), who argue that educational achievement gaps are fostered by the political-economic conditions of students, and without significant educational reforms that actually work, schools are doomed to failure .

In opposition to these negative views, other researchers have suggested that within-school reform policies could potentially reduce inequalities and achievement gaps. In the last twenty years, advancements in evaluation and program impacts have provided a clearer outlook on the complex environment that determines school outcomes (Jacob and Ludwig 2009). Data suggests that a number of programs can and have positively impacted the learning outcomes of low-income and minority students, despite the socio-economic barriers they face. For example, Brian Evans and Jacqueline Leondards found that low-income urban school districts provided evidence that the infusion of quality (i.e. strategic staffing of effective teachers), and initiating new academic programs assisted in improving student outcomes (Evans and Leonard 2013).

The intention of educational-technology integration into the schools and classrooms has been to assist teaching and learning outcomes of students (U.S. Department of Education 2007a; Gray and Lewis 2009). The Enhancing Education Through Technology (EETT) Act provides funding to promote this initiative by building a stable infrastructure, providing access, professional development, improving software and providing technical support. With significant changes being made to promote educational-technology in schools it is necessary to examine the relationship between the access, frequency and usage of technology and the impact it has on student achievement. Funding for educational-technology programs is an expensive endeavor, thus it is important to study how different types of technology can contribute and enhance learning outcomes.

If technology is yet another failed education reform initiative (Bianchi 2004; Cuban 2006; Vascellaro 2006; Cuban 2009), than the financial investments should be made to other more promising programs. However, if technology is a resource that is proven to help close the achievement gaps, improve disadvantaged student outcomes and produce more technology-savvy students for a computer-saturated career environment, then effective strategies of technology usage are worth expanding (Stallard and Cocker 2001; Edwards 2003; Swain and Pearson 2003; Vascellaro 2006; Gray et al. 2011).

The first round of the digital divide (or access-divide) has decreased dramatically over the last two decades. While in 1994, only 35 percent of public schools had access to the internet, in 2003 100 percent of public schools had access (Gray and Lewis 2009). Within a decade, between 1995 to 2005 instructional classroom computers doubled in public schools (Gray and Lewis 2009). The availability of technology resources for teachers and students have also increased dramatically, with 85 percent of public school districts supplying student assessment tools in both math and reading, 90 percent furnishing online curricula, and 87 percent providing server space to create blackboard or web pages to give class materials and homework assignments (Gray and Lewis 2009).

Despite the increase in technology investments across the country to provide more access, many low-income and urban school districts continue to lag behind. Access it not the only issue. Schools that serve disadvantaged populations often do not utilize technology to effectively support learning, and promote student outcomes (U.S. Department of Education 2013). Technology can potentially play an important role in decreasing educational barriers, as Becker (2001) and Lei and Young (2009) found that proper technology integration into the classroom can significantly increase student standardized test scores. Supporting their research, Wenglinsky (2005) and Tienken and Maher (2008) reported that students using technology for higher-order thinking math skills had higher achievement outcomes on math standardized exams; whereas student outcomes were negatively impacted when technology was used for lower-order thinking skills (i.e. drill and practice). Additionally, many studies have found that schools that served low-income elementary and middle school students used technology for lower-order tasks or didactic approaches (Cuban et al. 2001; Zhao et al. 2002; Zhao et al. 2002; Bain 2004; Cavanaugh et al. 2007; Cuban 2009).

Utilizing technology to support mathematic instruction in elementary and middle school has mixed results. Studies conducted by Lowther et al. (2003), Hunter and Greever-Rice (2007) and Shapley et al. (2010) have found a relationship between the type of technology used and student outcomes. In their studies, they found that math teachers who utilized technology for didactic approaches (i.e. fostering lower-order thinking skills, using drill and practice applications) had lower math student achievement outcomes. While teachers utilizing technology to support constructivist approaches (i.e. higher-order thinking, fostering critical thinking skills, and so forth) had statistically significant improvements on their students standardized math scores (Lowther et al. 2003; Hunter and Greever-Rice 2007; Mollette et al. 2009; Mollwrrw et al. 2010; Shapley et al. 2010). Yet, other research indicates that technology usage (didactic or constructivist approaches) does not directly relate to decreasing or increasing student achievement (Eagly and Karau 2002; Sclater et al. 2006; Dunleavy and Heinecke 2008; O'Dwyer et al. 2008; Bebell and

Kay 2010). With these controversial arguments, the Department of Education suggests that further research is needed in order to understand what educational-technology methods and programs are useful both in and out of school to improve disadvantaged student outcomes.

In support of the Department of Education's suggestions, the International Association for the Evaluation of International Achievement (IEA) and the Association of Mathematics Teacher Educators (AMTE), recommend that teachers need ongoing support and professional development to effectively integrate technology into curriculum. Studies have found that both pre-service and ongoing professional development courses can increase teachers understanding of technology integration, and how to effectively use it to build on the current curriculum and during instruction (King 2002; Kanaya et al. 2005; Swan et al. 2005; Swan and Dixon 2006; Silvernail and Buffington 2009). However, less than half of teachers in urban or low-income school districts reported receiving in-school or professional development training to incorporate technology into their curriculum (Darling-Hammond et al. 2009; Kleiman 2010; National Alliance for Public Charter Schools 2012). The strength of education-technology is to assist educators to utilize it effectively in their pedagogy, to deploy it in mathematical learning models and simulations to work in conjunction with in-classroom learning. In addition, the National Council of Teachers of Mathematics (NCTM) Principles for School Mathematics, strongly support educational-technology to enhance mathematics learning in the classroom; however, more research needs to be conducted on what types of integration tools are most effective (National Council of Teachers of Mathematics 2014).

Statement of the Problem

Since 2005, there has been a gap in the research literature related to the integration of technology and the extent to which it supports academic achievement in math among 4th and 8th grade students in the home and at school. Literature in the field has reported mixed results on how to effectively integrate technology in order to promote student outcomes. Determining effective technology integration into the home and school are two critical components that this dissertation will investigate and assess.

The first critical component to address is the home effects of technology on student achievement. Research on home effects of computer technology to support student achievement in math is inconsistent, and often inconclusive. Thus, understanding the most effective methods for technology usage in the home, and how those methods can positively affect student achievement in math is essential to comprehending the overall effects of technology on student achievement.

The second critical component is to conduct an evaluation at the *school*, *student*, and *teacher* levels to determine the most useful techniques to integrate technology into the classroom. At the *school* level, current research focuses on general outcomes measures (GOM) as it relates to school-wide academic achievement based on subgroup populations (i.e. socio-economic status, race, gender, etc.); however, what is lacking in the literature is determining if there are any differences in technology integration (access and usage) between urban, large-city, state and nation-wide programs (Ysseldyke and Bolt 2007). At the *student* level there is a lack of systematic studies on *students'* perceptions of their computer usage and how this affects their academic performance on standardized tests. At the *teacher level*, there is a lack of research on how *teachers*' technology training and competency with computers can affect the ways they integrate technology into the classroom to promote student learning. Specifically, there is little research on teachers' approaches to computers (i.e. didactic and constructivist) in urban and large-city environments.

Insight into how and to what extent schools, districts, and communities are integrating technology into math instruction has been limited. It is critical to expand the scope of technology integration research, by examining the issues from a multi-layered perspective, incorporating the social contexts of the home, school, teachers and students' perspectives into the equation. This research provides a critical perspective to enhance and develop new educational policy to promote effective technology integration programs into communities that are considered disadvantaged. Creating policies based on credible research can promote new opportunities for teachers to foster students' abilities to learn concepts by having the students construct math and reading knowledge (Association of Mathematics Teacher Educators, 2006). With the recommendations of the National Council of Teachers of Mathematics (NCTM), National Council of Teachers of English (NCTE), and the promotion of new educational policies, it has become important to confirm the effectiveness of technology in the classroom and the effect it has on student achievement. Evaluating the most useful techniques to integrate technology into the classroom to generate a positive result on student achievement is one critical component.

Conceptual Framework

Though the role of digital technology in schools has been an important policy question for more than a quarter-century (Culp et al. 2005), the U.S. seems to be at a tipping point on this matter as issues such as online education, e-reading, and "flipping the classroom" have come to the fore. Various theoretical frameworks have been utilized to explore the ways in which technology access and usage can benefit student learning. For purposes of this dissertation three major frameworks will be summarized below, the works of: Wenglinsky; Mishra and Koehler; and Cox and Graham.

Wenglinsky (2005) used NAEP data from 1996 and 2000 to investigate school computer use and its relationship to *individual* student academic achievement. He reported the frequency of different types of computer use at schools in fourth and eighth grade math, science, and reading; the frequency of different uses by diverse demographic groups; and the relationship of uses to individual academic achievement. By comparing data between 1996 and 2000 and holding constant other factors, Wenglinsky explored how changes in usage over time correlated with changes in test score outcomes. He found that overall technology use was negatively correlated with academic outcomes and that this negative correlation was most pronounced with didactic forms of technology use, such as for math or grammar drills. However, the use of computers for holistic purposes, such as for simulations, data analysis, or word processing, was correlated with improved test score outcomes, suggesting that higher order computer usage positively affected student achievement. Finally, Wenglinksy found that the negative relationship between computer use and achievement is particularly pronounced for students from low-SES families, presumably due to the particular types of computer use most common among low-SES students.

Extending Wenglinsky's analysis, Mishra and Koehler (2005) explored a technological pedagogical content knowledge (TPCK) framework as a way of explaining the integration of technology into school classrooms and the effects it has on student academic achievement. The foundation of their framework was based on Schulman's (1986) pedagogical content knowledge (PCK), which focused on the integration of teacher pedagogical and content knowledge and the effects it had on student achievement in disadvantaged schools. Mishra and Koehler's framework (TPCK) focused on five components of teachers: pedagogy, subject-specific content knowledge, technology proficiency, subject-specific content knowledge with the use of technology, and pedagogy and technology. Suharwoto (2006) and Suharwoto and Niess (2012) used the conceptual framework from Mishra and Koehler to examine the implementation of technology in classrooms and the effect it has on student achievement in math and science.

Cox and Graham (2009) further explored the TPCK framework to provide a precise definition of each aspect of TPCK, and examined how teachers integrated technology in mathematics classrooms. Cox researched teachers' decisions regarding the integration of technology in the curriculum at low-income and highly segregated schools. Cox found that teachers with less content and pedagogy knowledge of mathematics used technology more often for drill and practice, and had significantly lower student scores on standardized exams. Comparatively, teachers who had more content and pedagogy knowledge integrated technology as an additional teaching tool, and provided other forms of rigorous academic learning to the classroom environment had higher student scores. For this study, the TPCK framework is a conceptual lens through which research can examine the school effects of teacher pedagogy, preparedness, content knowledge, and technology proficiency in the successful implementation of technology into the classroom to improve student achievement.

The purpose of this study is to seek to build on and extend the analysis laid out by Wenglinsky's overall examination of school and home effects of computer technology on student achievement, and Mishra and Koheler's study on teacher preparedness, competency and technology proficiency on the integration of technology into the classroom and its relationship to student achievement. Using these conceptual frameworks, this dissertation will provide an examination of the integration of technology (access, frequency and use) into the home and classroom, and its relationship to student achievement in 2011, by examining NAEP subject based data - in mathematics.

Purpose of the Study

For decades, Americans believed that education was the great equalizer. The educational environment was intended to fulfill the fundamental promise to provide a gateway of opportunity for all groups, and a number of policies since the 1960s have been implemented to promote equality and improve student achievement. Since the mid-60s national and state policies have focused on school improvement programs, funneling financial resources into disadvantaged communities in the hope that additional resources for schools would improve student achievement gaps. In the late 90s, however, national and state policies began to focus on technology integration into the classroom and home. Despite the increased use of technology in classrooms students in urban school districts still lacked technology resources.

This study wishes to determine if students' access and use of instructional technology is a significant predictor of fourth and eighth grade math achievement test scores. This quasi-experimental[1] research study will analyze the results of the 2011 fourth and eighth grade composite mathematics score of the National Assessment of Education Progress (NAEP). The analysis will focus on the academic performance of students in four Trial Urban Districts Assessment[2] (TUDA), by comparing their scores to aggregated large city (LC) populations and the national sample after controlling for the effects of

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1. Quasi-experimental designs lack a randomly assigned group of student participants that received the intervention of technology.

2. Results from Large City (LC) variable is aggregated data for all large cities nationwide. This data for LC's are comprised of students in public schools located in urbanized areas of cities with populations of 250,000 or more, have a majority of students that are Black or Hispanic and are eligible for the National School Lunch program. LC data is not broken down at the school-district level. In 2001, the National Center for Education Statistics and the National Governing Board Association decided it was important to disaggregate large cities, and review school district levels for specific urban areas. TUDA was created to analyze data at the school district level. The data from the TUDA school districts are incorporated into the Large City (LC), state and national samples. For example, student results reported for TUDA-Boston, also will be integrated into the Large City, Massachusetts and national results. TUDA-Boston results are properly weighted so that their contribution to the state results reflects the actual proportion of students in the population (National Center for Education Statistics 2014).

NCES uses the national public school sample as a benchmark to compare results at the state level, LC data is used as a benchmark for comparing results for the urban school districts (TUDA). TUDA is compared to students in LC because the demographic characteristics of those students in urban school districts are overall similar with higher percentage of lower-SES, Black or Hispanic and English language learner (ELL) students.

race, gender and socio-economic-status. The four TUDA's were selected based on their racial demographics or the technology focus of the area, and include the following: Chicago as the demographics have almost a 50-50 split of African-American and Hispanic, District of Columbia's focus is on African-American's, Miami focus is on Hispanic's, and Boston were selected for their communities technology advancement.

Research Questions

My research questions begin with technology *access* as a starting point, identifying which urban school districts continue to lag behind large cities and the nation in terms of equitable distribution. From there I address the question of *use,* analyzing the ways in which students deploy new media for educational purposes. Factors that I analyze when exploring use encompasses three areas: home usage, students' self-reports of instructional technology in the classroom, and teachers' reported students' use of instructional technology in the classroom. I then address the question of technology *training* and assess how teachers' computer competency affects the types of approaches they use for technology integration into the classroom. Finally, I address student outcomes, considering how participation in technology at the home and in the classroom affects achievement on the NAEP standardized exams.

This study addresses the following five research questions:

1A. How is technology distributed (access) in the home?

  a. Are there patterns of equitable access in terms of race, gender and socio-economic-status?
  b. Is there a relationship between access and student achievement?

1B. How is technology distributed (access) in the school?

  a. Are there patterns of equitable access in terms of race, gender and

socio-economic-status?
  b. Is there a relationship between access and student achievement?

2A. How do students use technology in the home for math study?
  a. Is there a relationship between technology used in the home for math study and math achievement?
  b. What combination of home-technology usage variables affects math achievement the most?

2B. How do students use technology in the classroom for math study?
  a. Is there a relationship between technology used in the classroom for math study and math achievement?
  b. Is there a relationship between didactic math approaches to technology use and math achievement?
  c. Is there a relationship between constructivist math approaches to technology use and math achievement?

2C. How do teachers use technology in the classroom for math study?
  a. Is there a relationship between technology used in the classroom for math study and math achievement?
  b. Is there a relationship between didactic math approaches to technology use and math achievement?
  c. Is there a relationship between constructivist math approaches to technology use and math achievement?

3. How does teacher computer competency affect the types of computer technology they use in grade-four math classrooms?

Significance of the Study

Funding provided to support technology and increase computer usage in schools has increased dramatically over the last two decades. Kleiner (2003) reported that in 1996 states awarded $81 million to support instructional technology, in 2006 Greaves and Hayes (2006) reported that number increased to $6.8 billion, and in 2012 O'Dwyer found that funding for computer-based technology in public schools reached $10 billion (O'Dwyer et al. 2012). As these numbers grow to support technology integration into classrooms, many school districts have also had to make cuts that affect students such as:

laying off teachers - which increases class size, cutting extracurricular activities, eliminating field trips, and cutting instructional and professional development programs for teachers and staff (Husch, et al. 2010). More importantly, urban schools which have higher concentrations of poverty and students in need often have larger cuts. For example, The Pennsylvania State Education Association found that in 2011 the state-wide funding cut was roughly 11 percent; however, for urban school districts such as TUDA's School District of Philadelphia, the average cut was 13.8 percent.

As states and urban school districts across the nation cut funding in particular areas, technology financial support continues to be on the rise. In 2011, Maine, Maryland, California and Massachusetts cut state support to several urban school districts, decreasing or eliminating teaching positions in art, music and physical education; however, at the same time increasing funding for computers, one-to-one lap tops, and other computer aided software. Even though public and urban school districts are investing heavily in technology instruction aiming to improve student achievement, it has not been demonstrated that these programs are effective in increasing student outcomes. As more dedicated funding is being filtered into these programs, it is necessary to determine what type of technical initiatives are effectively impacting student achievement. Wenglinsky (2002) and Lei and Young (2009) found varying student outcomes based on different types of computer usage in the classroom; however, the analysis was only conducted at the national-level, and it is important to determine the effects at the state and community level (urban and large city school districts). With the gaps in the literature, it is important to address the multi-layered relationships that exist at the home, school and classroom levels. Focusing on how the effects of technology integration on student achievement at each of these three levels.

If a relationship is determined, this research can contribute in highlighting the best policies and procedures for educators using technology instruction particularly in urban community areas where there are concentrations of high-poverty and a lack of resources, teacher quality and professional development/training. By identifying the most effective instructional math practices and methods of technology integration and implementation in the classroom, this research could add to the literature to help decrease academic disparities based on race and socio-economic-status in math achievement. Furthermore, this research can hopefully determine the most productive programs in terms of cost per-pupil, and cheaper alternatives to effectively train and develop professional programs in technology for teachers (King 2002; Kanaya et al. 2005; Swan et al. 2005; Wenglinsky 2005; Swan and Dixon 2006; Silvernail and Buffington 2009).

Limitations of the Study

There are many benefits to utilizing the NAEP national data set including: (a) generalizability due to large-scale representative samples gotten every-other year, (b) access to variables related to computer technology in mathematics classrooms, and (c) adequate power to produce results that are statistically significant. However, there are a number of limitations to using the NAEP 2011 data set as well.

First, there were a limited number of technology focused questions on the NAEP before 2009. NAEP started collecting technology data in 2005; however, the questionnaire(s) only addressed five questions on computer use in the classroom for grade four, eight questions for grade eight, and one question on technology specific to teachers professional development. In 2009, NAEP added six questions on technology in the home, six additional questions on teachers training and professional development in technology, fourteen additional questions on computer use in the classroom for grade four, and sixteen additional questions for grade eight. Since NAEP only collected variables relating to computer technology related questions for two collection periods a long term trend can not be assessed. Thus, this study will only analyze the most recent restricted NAEP data for the year: 2011. This is a limitation to the study as the analysis can not examine change over time.

Second, the data in this study reflects access, frequency, and technology usage and the relationship these have on math student achievement for 2011. This study reviews data from nearly five-years ago, and since technology is constantly changing, and advancing new programs, software packages, professional development tools, and curriculum integration it is plausible that technology integration today (2015) might provide different results.

Third, the study is limited to studying achievement of elementary and middle public schools because a more substantial amount of funding from EETT competitive grants are dispersed to public schools, compared to private schools. The study focuses on elementary and middle school (grades 4 and 8) because research finds that student achievement at the elementary and middle school level is a predictor of higher grade achievement (Clark and Peterson 1986; Hunter and Greever-Rice 2007).

Fourth, student and teacher supplemental questionnaires that address home and school technology access, frequency and use are voluntary, and respondents are not required to participate. Despite this limitation, response rates are weighted to match the demographic composition of the teacher and student population; and any voluntary questions that have potential non-response bias are identified in the study and excluded from the analysis.

Fifth, the analysis only focuses on 4th and 8th grade math students, and the external generalizability of the results is limited to the use of technology in these grade levels and subject. The effect of technology integration at the home and in the classroom on student achievement can differ based on grade-level and subject, and thus the results can not make any assumptions about high-school math or any other subjects (Becker 2001; Barron et al. 2003; Antonietti and Giorgetti 2006; Dunleavy and Heinecke 2008; Cuban 2009; Bebell and Kay 2010). Similarly, teachers professional development, and technology use may be different by grade-level and subject, so findings from this study cannot be generalized to high-school math or any other subject areas. Additionally, the analysis on computer competency measurements only addressed fourth-grade teachers. Therefore any relationships that may exist cannot be generalized to eighth-grade or high school math teachers.

Finally, other factors not incorporated in this study may influence students' achievement on the NAEP exam, and there are limitations to the correlations that are identified in this study. Additional factors may include, but are not limited to, home variables that are not measured in the NAEP (i.e. religion, household income, parent involvement, etc.); students with learning disabilities having lower test scores; programs implemented throughout the school district in an effort to raise test scores; after-school tutoring programs that may be offered in math and reading; curriculum changes in math and reading during the years studied; as well as additional teacher professional development courses and additional resources that support teaching curriculum.

Assumptions

The study made a number of assumptions about the accuracy of self-reported NAEP student-level, teacher-level, and school-level data.

At the student-level, parents or custodial guardians self-report the core background variables (i.e. parent educational background, and race). Students report on the amount of time spent at home using the internet, and the type of computer activities (i.e. e-mail, messaging, blogging) to get reading and math help. At school, students respond to a series of questions that ask the respondents to determine to what extent they use technology in their reading and math classrooms. It is assumed that the students reported accurately the number of times and the type of technology used in their math and reading classes.

At the teacher-level, teachers must self-report their educational background, professional development, and computer training and proficiency levels. Additionally, teachers report about their classroom instruction and organization, specifically reporting on the number of computers in the classroom, how frequently the student uses the computer for math and reading related activities, and the type of software programs the students use on a daily basis.

At the school-level, schools are required to track and report clearly defined variables set out by the U.S. Department of Education, and reported as part of their NAEP testing. It is assumed that the school administrators understand those definitions and are accurately tracking and reporting on each variable.

Summary

This study is a critical analysis of the future of technology integration in math pedagogy, content and classroom instruction. By better equipping our schools, administrators and teachers with a guide to effectively incorporate the necessary technology skills in the classroom, we can promote student achievement and narrow the achievement gaps. This study's aims to find the most effective use of technology connected with positive student outcomes in order to implement research-based methods to close the achievement gaps. School leaders, and teacher training programs can utilize this information to successfully incorporate high-tech alternatives into the classroom. The U.S. Department of Education (and, by extension, lawmakers, and policymakers) can properly fund programs and initiatives that will actually bring about results and maximize student opportunities for academic success. Furthermore, providing the necessary technology skills not only supports student academic achievement, but provides our students the ability and competencies necessary to compete in a technologically advanced national and global labor force.

This chapter is an introduction to the research study, and includes a brief overview of the background of the study, the study's purpose, a review of the conceptual framework, the base and expanded research questions, the significance of the study, the limitations, and the assumptions. The second chapter provides a theoretical framework to consider how technology has been integrated at the institutional and organizational levels of the education system. The second chapter also highlights the importance of social movements that have shaped and changed the education system in the U.S. over the last two centuries. Additionally, the theoretical framework calls attention to how: race, gender and socio-economic-status created differences in educational opportunities. Chapter three provides a brief historical account of segregation issues related to minorities and the impact they have had on student achievement and gaps in outcomes. This chapter explores how social and political movements since the 1960s has attempted to create equitable educational opportunities for all students by increasing financial resources to school districts. In the early 2000s, national and state funding was utilized to increase access and usage of technology in the classroom to improve student outcomes. Researchers and educational practitioners believed that integrating technology could potentially equalize educational opportunities in disadvantaged areas; however research on the impacts of technology has been inconclusive. Thus, the remainder of chapter three focuses on the current debates of technology usage in the home and within the classroom to improve student outcomes. Chapter four reviews the methodology for the study, describing the NAEP data set, the variables selected for the study and the statistical methods used to address the research questions. Chapter five presents the results of the analysis, and finally chapter six provides empirical implications and suggestions for future research on technology integration to improve math student achievement.

CHAPTER TWO: THEORETICAL FRAMEWORK AND CONCEPTUAL MODELS

Over the last century, there has been an ongoing debate about the quality and impact of technological advances in the United States, with an emphasis that technology should be ordered, rational and controlled by the users. Technological advances have been useful in so many ways and have expanded our ability to communicate, network globally, increase productivity and create avenues to rectify societal issues (Boorstin 1973; Segal 1985). Technology has been utilized in U.S. educational systems to bring about efficiency, growth and productivity. As early as the 1960s, information technology solutions entered into educational classrooms to promote productivity, advancement, order and efficiency. Minicomputers and mainframes entered the higher education environment; in the 1970s and 1980s, personal computers (PCs) were introduced; and by the mid-1990s, multimedia technologies, e.g., CD-ROM-based audio and video, and the internet were available to schools (Wenglinsky 2004: 12).

Sociological theories point to how technology is a resource that has been unequally distributed throughout the nation, thus significantly impacting disadvantaged groups. Specifically, conflict theory suggests that power holders limit resources in order to suppress certain groups such as minority and low-income students. Educational institutions and organizations support the dominant groups position by ensuring that resource availability is limited or inappropriately used with disadvantaged groups. As resource inequalities grow over time, conflict builds between the dominant and suppressed groups which often leads to social movements. The goal of these movements has been to decrease the conflicting situation between groups by providing changes to educational policies to promote equality. In order to explain this cycle, this theoretical chapter provides an overview of conflict theory and how it can be applied to the study of technology. In particular, it discusses how conflict theory can address some of the underlying achievement gaps and inequalities that have been a historical issue.

First this chapter explores a broad overview of *conflict* theory, highlighting the foundation of Marxism in order to describe the association between the historical forms of oppression and its impact on the current issues of power and power relations in our society. Class positions have historically created systems of stratifications which have supported the roles of social domination through the use of power, authority and coercion to subordinate and repress disadvantaged groups into a state of powerlessness. Dominant groups in power construct social, economic and political structures to support the most favorable outcomes and opportunities for themselves, while restricting access and opportunities to those in subordinate positions. Educational institutions and organizations are structures of power dominant groups that have been utilized to maintain authority, privilege and power by controlling access to resources. Educational inequalities are simply an avenue used in the exploitation and oppression of subordinate groups.

Based on the concepts in conflict theory, this chapter examines how elite groups maintain their power by controlling the structure of educational *institutions* and *organizations* through the creation of specific school practices, approaches to design and pedagogy, systematic methods in the classroom, and withholding resources in order to suppress disadvantaged students (Meyer 2006). The primary interest is in the role that educational technology plays within the school organizational environment. The sociology of "school organization" refers to the administration of schools, organization of the classroom, interaction between teachers and students, interaction among students, interaction among teachers, and how the work environment is organized to accomplish stated goals (Laczko-Kerr and Berliner 2002).

Next, this chapter focuses on the role of conflict theory during *social movements,* specifically as they seek to promote education reform and create policies to advance equality in education. Social institutions are modified continuously based on the changing social environment, which then alters conditions and circumstances into new forms. Social movements and reform policies have focused on the role of education as the primary engine for promoting equal opportunities for all groups. Over the last twenty years, educational technology has played a key role and facilitator in institutional and organizational change. Thus, student achievement gaps can only be understood through the literature on the shifts in society and the relationship between social movements and social changes as they pertain to the interaction between education and individuals or groups.

Then, I connect how conflict perspectives explain differences between race, gender and socio-economic-status, perpetuating inequalities in educational attainment. Specifically, as *sociology of individuals* examines how people voluntarily affiliate with a particular demographic group, or are involuntarily ascribed to a demographic group.

Historically, conflict has been attributed to the educational institution, as the system has been a catalyst to either promote or restrain groups based on individuals' ascribed status. Statuses are reflected in how an individual defines themselves based on race, and class and how society characterizes that group as being in an advantaged or disadvantaged position. I focus on how historically and currently education manages each of these groups and how educational technology interacts within these groupings (Kerr 2008).

Lastly, I explore educational perspectives on teacher contextual issues as it affects student outcomes and potentially explains the achievement gaps. First, this section explores two different approaches to teaching mathematics in the classroom: didactic and constructivist. Teachers that use didactic approaches focus on drill and practice models, while constructivist approaches creates an open-ended learning environment. Focusing on these two approaches the paper explains a theoretical model for measuring didactic and constructivist approaches to technology in the classroom.

Sociological Theory: Conflict

The first overarching theory that is woven into the dynamics between dominant and suppressed groups is the role that conflict plays. Conflict perspectives view the social sphere as "a figurative battlefield upon which contending social factions struggle for control of scarce resources such as wealth and power" (Rigney 2001: 67). Opposing groups based on class, race, or gender are either in the role of domination or suppression. Anderson and Taylor (2001: 176) highlight conflict theory related in analyzing social inequalities. They assert that competition and conflict between classes are based on the struggle for power and authority, as well as financial and political resources. As the dominant group controls the resources and forces the subordinate group into a submissive role, inequalities arise and expand. Those in power then maintain their power by shaping policies and belief systems to ensure that the powerless remain subordinate and in an even weaker position. Marginalized groups remain in a cycle of subordination and are unable to climb the social ladder as they are given fewer opportunities. This results in large inequitable divides based on class and race (Shapiro 1998).

The overarching perspective of conflict theory sheds a theoretical light on how educational inequalities are created and maintained by summarizing three major concerns (Ballou and Podgursky 2000). First, with respect to education, conflict theorists focus on historical issues that have emerged from free, compulsory education (Cole 2008). Compulsory schooling began during the late nineteenth century with the goal of imposing uniformity and enforcing equality. By creating a nationwide standard of education, the intention by many was to prevent immigrants' values from corrupting the established "American" values (Thomas 2002). Many conflict theoriests believed that compulsory education was a form of *ethnocentrism*, or the belief that one's own group is superior to another group (Campbell and Pendersen 2001; Manza and McCarthy 2011). The transmission of beliefs, norms and values were estabalished by the dominant group in what many call a "hidden curriculum." For example, during this late nineteenth century the dominant group intentionally created a curriculum designed to serve the interest of the upper class, and provide limited opportunities to teach working families the skills they needed for the new economy. Despite the negative connotations associated with compulsory education, it did provide an avenue for blacks in the south to advance intellectually and economically in society.

Social reproductive theorists (Bernstein 1975; Bowles and Gintis 1976; Bourdieu 1977) argue that schools continue to support the transmission of class structure by teaching students to acquire their place in society (i.e. dominant or subordinate roles). This theory views schools as perpetuating the capitalist hierarchial system through formal and hidden aspects of learning and curriculum standards. Formal curriculum refers to the skills and understanding that a teacher expects to teach to their students. While hidden curriculum refers to how and what students acquire from participating in school outside the official curriculum standards set by the state.

Althusser (1971) argued that both formal and hidden curriculum in schools assisted in maintaining the position of the dominant class within society by teaching dominant ideology so that children would understand their place and did not challenge the class structure. Schools become organizations that perpetuate the ideological state values, sustaining the dominant class position and creating a form of symbolic violence. Thus, schools represent the dominant ideology by filtering the applicable skills, knowledge, and material relations needed to withold the dominant groups position.

Adding to this, Gramsci (Mayo 2010) extended the concept by examining the differences in learning environments accessible to dominant and subordinate groups. He argued that students in subordinate classes dealt with more educational constraints and barriers, which challenged their ability to improve their class position. Both Althusser and Gramsci believed that even though policies attempt to enforce equal intellectual opportunities by providing standard formal education, inequalities will continue to plague schools as dominant ideology continues to be the ideas transffered in the classroom.

While Althusser and Gramsci focused on social class as the basis of social reproduction, others posit that race plays a dominant and undiminished role in perpetuating educational inequalities (Fordham and Ogbu 1986). Ogbu (1978) contented that the foundation of racial stratification entails limits on access to opportunities due to historical barriers that include economic, social and residential issues that have isolated blacks into an oppressed state. Due to these barriers, many disadvantaged students are segregated into low-quality schools that have limited resources and opportunities for student success.

Second, conflict theorists focus on the differences in the quality of schools. U.S. schools differ vastly in their resources, learning conditions and other aspects, all of which affect how much students can learn in school. Simply put, schools are unequal, and the varying forms of resource inequality helps perpetuate inequality in the larger society. Since schools are primarily funded through property taxes, schools in poorer districts have less available funding to provide their students with equal resources (Moynihan 1965; Jencks and Phillips 1998). Thus, children attending schools in poor urban areas face resource obstacles such as quality teachers and updated text books and technology. Their lack of resources creates a disadvantaged learning environment, which helps ensure they remain trapped in the cycle of poverty and its related problems.

Third, conflict theory states that the process and function of standardized tests perpetuate social stratification and inequality in American education through cultural biases. According to conflict theorists, national standardized tests favor white, middle-class students whose socioeconomic status and other aspects of their backgrounds have afforded them cultural experiences that help them answer questions on the test that focus on cultural knowledge (Grodsky et al. 2008). ETS claims that NAEP standardized exams are culturally neutral; however, conflict theorists believe that is impossible as all standardized exams are based on knowledge that is culturally sensitive.

Sociological Theory: Institutions and Organizations

The conflict that occurs between groups within the social structure is supported and maintained by the existence of social *institutions* and *organizations*, which is the second major theme that supports the argument of achievement gaps. Institutions create conditions that perpetuate the belief systems and social patterns of inequalities (DiMaggio and Powell 1991b). They are defined as a dynamic and complex social process based on a "set of complementary social practices and meanings, routines, practices that form taken-for-granted background rules that shape social life" that are embedded into organizational structures (Berger and Luckmann 1966). Both the institution and organization provides actors and groups with pre-defined sets of belief patterns, establish normative rules, cultural and cognitive regulations, and meanings to stabilize relationships and interactions to serve societal functions.

Using this definition of an institution, this study focuses on the function of an insitution to create and maintain social inequalities between the dominant and suppressed groups in the education system in the following ways:

1. *political institutions* that regulate and control access to power and opportunity through policy initiatives;

2. *economic institutions* that control the unequal access to production, distribution, regulation and consumption of goods and services (i.e. technology access);
3. *institutions of social stratification* that regulate access to knowledge from one generation to the next (DiMaggio and Powell 1991a; DiMaggio and Powell 1991b).

More specifically, throughout history dominant groups have utilized *political institutions* to maintain their control over disadvantaged groups by creating a system of laws which supported their elite positions. Through these politically mandated laws, education was constructed to provide a system of informal and formal organizations to successfully instill cultural values, socialization and training of various populations. From an historical context, political institutions have established that the education system should be a differentiating agency, providing "education according to social station" (Bowles and Gintis 1976) and elites have exercised differential power over the definition and distribution of knowledge. Floud and Halsey (1958) and Meyer (1977) argued that educational institutions historically functioned to allocate groups into particular categories based on their race and SES, which created both intended and unintended consequences. Thus, throughout history educational institutions and organizations have played a causal role in the determination of social stratification by controlling the spread of existing and new knowledge and limiting resources to disadvantaged groups (e.g. women, minorities, and low-income students) (Collins 1971; Bowles and Gintis 1976; Bernstein 1977; Bourdieu 1977).

Second, those in power maintain control over *economic institutions* by ensuring that the market and its resources are kept within the boundaries of their group. For example, Wilson (2009) found that political and economic forces have directly and indirectly contributed to and reinforced longstanding labor market segmentation between racial groups in the United States. He argued the concept of marketization maintain that those in the dominant position has access to economic resources, which increases their ability to "choose" the type of educational opportunities for their children. They also argue that those in disadvantaged groups are underprivileged, lacking access to the available markets and resources. Thus, the marketised approach continues to perpetuate segregation, as individuals in disadvantaged groups are not given a choice in the educational resources they can utilize.

Finally, *institutions of social stratification* occur at the macro-level institution as the dominant group regulates access to the transmission of knowledge justifying it based on the system of social stratification. This in turn affects the micro-level oppressed actor, by constructing and supporting their suppressed social and cognitive position. This social stratification system continues from one generation to the next and maintains the cycle of inequalities. One way this macro-level to micro-level institution is apparent is in the education system where the dominant groups exercises its position through a series of macro-level socialization and allocation functions, controlling the dissemination of knowledge and access to the actor. Educational institutions influence the nature of stratification in the social order through these power relations established at the macro-level to suppress various disadvantaged groups (Sewell 1998).

Sociological Theory: The Role of Social Movements

A third major focus of this study is the role of social change, social stability and social movements during conflicting situations. This section addresses common threads in theoretical discourse on the effects of conflict as a means to materialize, organize, process, grow, decline and create new adaptations to educational institutions and organizations through social movements. Particularly the goal of many social movements has been to decrease the conflicting situation between groups by providing changes to educational policies to promote equality.

Karl Marx was the first classical theorist who posited the perspective that based on the scientific laws of economics and the historical developments of class conflict and class identification, society could not avoid radical reconstruction through newly mobilized social movements (Marx 1867). Marx's concepts can be employed throughout history, as educational organizations have experienced dramatic systematic and structural changes due to conflicting situations which has spurred social movements.

In contemporary theory the most widely cited definition used to describe a social movement is a "sustained series of actions between power holders and persons successfully claiming to speak on behalf of a constituency lacking formal representation, in the course of which those persons make publicly visible demands for changes in the distribution of exercise of power, and back those with public demonstrations of support" (Tilly 1998: 87). Tilly's theoretical argument is that social movements are derived from a population's collective action against national power structures that are enforcing dominant interests and beliefs (Tilly 1978: 19). If a social movement is fragmented, "shifting factions, temporary alliances, diverse interests or is in a continuous flux of members" then power holders protect their interests through bargaining, coalitions, and forms of repression. In order for the social movement to be successful, the leaders of the movement must mobilize large numbers of supporters, make good strategic choices and be unified. Furthermore, the interaction between the actors advancing their interests and the power holders must be sustained over time.

Other contemporary theorists such as Della Porta and Diani (1999) find that social movements exist because of "contrasting value systems and of groups in conflict with each other;" these variances construct new norms and transform institutional and organizational systems and structures. Giddens (1990) and Touraine (1995; Touraine 2007) further examine the emergence of social movements through the social and cultural conflict between the have and have-nots within society. Providing an extension to conflict theory, Aminzade and McAdam (2002), and Gerlach and Hine (1970) provide explanations for 21st century social movements, stressing the importance of two theories to explain why people mobilize for change: *relative deprivation* and *resource mobilization*.

Relative deprivation occurs when one groups has a negative perception of the differences they are experiencing compared to another group, which reinforces the conflicting experience. The limited opportunities that one group can experience may include inadequate resources and privileges that are accessible to other groups. For example, members of minority and low-income groups may feel relatively deprived of quality teachers or resources such as updated technology; these differences create tension between those that have resources and those that do not. From this, a social discontent is experienced by disadvantaged groups which can eventually be expressed in terms of a social movement. Members of the disadvantaged group utilize their collective action to organize, generate or modify a social institution or organization. Through community organization or “the work that occurs in local settings to empower individuals, build relations, and create action for social change,” social movements succeed to decrease the struggles of the community (Stall and Stoecker 2007).

Resource mobilization occurs when social movements generate resources through personnel, mass media, or financial funding to support the movement, recruit members and ensure the growth and stability of the movement. The magnitude of the impact and success of a social movement depends on the type of resources mobilized by the members. Often the success of the social movement is based on the ways that the members emphasize the strategic problems faced by the group and what types of fundamental changes will be needed to improve the conditions. Thus, powerful social movements have assisted in highlighting injustices and then defusing conflict between groups by facilitating positive changes in the institutional and organizational structures to promote equal opportunity.

Sociological Theory: Individuals and Demographics

The fourth major area of sociological theory addressed in this study involves individuals and the significance of their demographic membership for their life chances. This draws attention to the individual’s specific ascribed membership to a particular group where an actor is a member of a specific demographic group based on their race/ ethnicity, gender, and income. Ascribed group membership is of particular interest as there are specific historical social barriers to education that have been placed on actors based on their ascribed status. Structural discrimination policies have limited the opportunities of individuals based on race, gender and class and account for reasons behind differences in educational attainment.

First, to conceptualize the dominant paradigm of race/ethnicity and what it means to have an *ascribed membership* to one particular racial group, Omni and Winant offer a racial formation theory. Their theory states that "the socio-historical process by which racial categories are created, inhabited, transformed and destroyed...[It] is a process of historically situated projects in which human bodies and social structures are represented and organized." In addition, they connect "racial formation to the evolution of hegemony, the way in which society is organized and ruled" which suggests that "race is a matter of both social structure, and cultural representation" embedded in institutions and organizations.

Second, stemming from historical discourse on *racial formation theories* is the intersection of race and poverty and the effects of social structural barriers. Both the theoretical approaches of Collins (1971) and Wilson (2009) illustrate how minorities have been characterized by concentrated areas of poverty and have been historically susceptible to structural economic shifts as high-paying manufacturing positions, which require little academic skills, have moved out of urban areas, leaving them without employment. This in turn creates a polarization of the labor market into low-wage and high-wage sectors, producing new barriers that intensify poor people's belief in the education system as an avenue out of poverty conditions.

Third, theories that explain racial and income inequalities focus on structure of society, making deductions based on etiological variables. *Structural discrimination* theory maintains that social and political forces are created to systematically enforce barriers to deny suppressed groups the ability to access opportunities such as education which would benefit their life chances. Throughout history, structural forces have evolved to ensure institutional discrimination practices in order to exclude subordinate groups through "activities and practices which are intended to protect the advantages of the dominant group and/or maintain or widen the unequal position of a subordinate group." One example of structural discrimination is when the system *allocates* disadvantaged individuals (i.e. minorities and low-income) in order to maintain the social privilege of others, creating a marginalized group by powerful institutional and organizational structures. Allocation models find that individuals are strongly affected by social institutions, and what that persons achieves (i.e. student outcomes) is determined by what resources the institutions provide. Thus, the accomplishments of a student's outcome is subject to the structural constraints, selective criteria applied in the education system and obstacles that the actor can not control.

Furthermore structural discrimination continues to illustrate the allocating power of schools, which has created and validated racial and income categories. Schools continue to provide legitimacy of these categories and broadening the whole rationalized modern social structure. By legitimizing the effects of schools, it intensifies the effects of allocating and socializing processes, disseminating resources to those that are in higher or more privileged social classifications. Thus, educational institutions and organizations play an interactive role that influences both cognitive and normative outcomes, as schools provide a context that impedes the positive educational growth of minority and low-income students (Freeman 2007; Lareau and Conley 2008).

Education Model: Measuring Teaching Approaches to Learning

> "Tell me and I will forget; show me, and I may remember; involve me and I will understand" - Chinese saying

This dissertation turns to an educational perspective to identify teacher contextual issues, specifically as it can limit their abilities to effectively integrate technology into the classroom. This section provides an explanation to two models of teaching mathematics in the classroom – didactic and constructivist. Didactic approaches focus on drill and practice models while constructivist approaches create an open-ended learning environment.

There are a variety of approaches to understand how teachers construct learning in the classroom, and how students receive and process the information. The current study seeks to explore the relations of technology instruction (constructivist and didactic) to students' academic performance on math because a large body of evidence has shown that different approaches to teaching can contribute either positively or negatively to learning and academic performance. Utilizing learning theory can support the proper methods to integrating technology to bolster a productive math classroom (Muniandy et al. 2007).

Didactic Approaches: The more traditional approach, didactic theory, to learning is based on teacher-centered instruction and knowledge-transmission approach which is based on a model of drill and practice techniques (Hickey et al. 2001). This approach to learning is focused on the transmission of knowledge based on a curriculum that is centered around textbooks, in which the students become passive players in the knowledge-transmission system of learning. Hopkins (1994) reported that traditional education relies on a teacher-delivered theoretical model of direct lecture and rote based instruction, which does not provide overall strategies on how to solve problems or give the opportunity for students to gain meaning from the subject matter. Technology used to support didactic instruction emphasizes drill and practice, which supports a student's ability to memorize information.

Constructivist Approaches: Since the mid-1990s, constructivism or student-centered instruction has emerged as one of the dominant theories to learning and cognition (Phillips 2000; Richardson 2003). There are various constructs to constructivism approaches (Phillips 2000); however a core theme that runs throughout is that "learning is an active process of knowledge construction and meaning making by the learner" (Nie and Lau 2010: 411). Driscoll (1994) summarized five basic assumptions of constructivism theory to learning in the classroom. First, the theory focuses on how students should learn to solve complex problems in the classroom that they would face in the real-world "providing complex learning environments that incorporate authentic activity" to students. Second, Driscoll states that it is necessary for learners to have the opportunity to collaborate with others so that they can have multiple perspectives for learners to negotiate processes in subject-specific content areas. The third assumption is to "juxtapose instructional content and include access to multiples modes of representation" or in other words to "revisit the same material at different times, in rearranged contexts for different purposes, and from different conceptual perspectives is essential for attaining the goals for advanced knowledge acquisition" (Spiro et al. 1991: 28). Thus, representation materials in different perspectives will benefit the learner to view the same content in different modes of learning. Fourth, Driscoll states that learners need to "nurture their reflexivity" or "be aware of their own role in the knowledge construction process;" this is an important concept as it ensure the learner is aware of how and what meanings they tie to the content they are learning. Finally, Driscoll emphasizes that constructivist theory is "student-centered instruction" where the student is the "principal arbiter in making judgements as to what, when, and how learning will occur." These five constructs are the basic assumptions of the constructivist conditions for learning.

Given these basic assumptions of constructivist approaches to learning, this method of instruction allows the teacher to take on a role of facilitator, giving appropriate activities to the students, while allowing the student to independently explore subject specific concepts, frequently through hands-on group activities. The students learn the concepts by building their knowledge of the world through the individual or group hands on experiences and then thinking about those experiences after they are done (Frid 2001). Through this, students take an active role in the learning by evaluating effective strategies, principles and concepts that they need to comprehend in order to understand the content. Evidence has supported that constructivist learning environment bolster cognitive activity through active, self-led direction. Thus, constructivist approaches focus on students' ability to process information and apply it to more abstract problems (Mayer 2004).

There are many benefits of constructivist approaches to technology to improve student outcomes. Many theories have indicated that a student-centered approach to learning enables teachers to improve the learning process from basic didactic approaches to high-order thinking skills (Rakes et al. 2006). Teachers who are student-centered and employ constructivist techniques enable "students to use technology to build their own understanding of information by incorporating authentic experiences into project-based learning situation" (Rice et al. 2013: 10). Marsh (2005) suggested that there are advantages to learning with the web when teachers use technology so students can be self-directed and independent understanding concepts in a more abstract and applied way. However, Marsh also described a number of weaknesses to constructivist approaches using technology. First, he found that constructivism focused on the meaning derived from the participants; if those meanings are skewed or distorted, then online learning will inappropriately support those inaccurate meanings. Second, since meaning is based on the individual perceptions, only one meaning is possible to develop at a time.

Incorporating learning theory such as constructivist approaches, into how to effectively use technology can promote productive classroom learning (Muniandy et al. 2007). Researchers, education leaders and policy reform initiatives have focused on shaping classroom environments and instructional practices utilizing a constructivist approach to support a student's understanding of knowledge. The active process of constructivist theory has been widely supported throughout the educational community; however, there is considerable controversy in literature on the true effectiveness of the instructional practices in the classroom (Kirschner et al. 2006). Scholars have made great efforts to study how educational-technology can be effectively integrated into the classroom to impact student outcomes. Studies have supported the use of technology integration into the curriculum, specifically for elementary and middle school students (Hill et al. 2005). Yet, there has been little focus on the link between disadvantaged students (based on race, gender and income), particularly those in urban school districts, and the association of technology integration theory as it relates to student math achievement.

A Model for Measuring Didactic and Constructivist Approaches.

Over time there have been various models used to define and measure teachers' approaches to student learning (Glennan and Melmed 1996). In the previous section, didactic and constructivist approaches to learning were highlighted as the two theoretical approaches to learning styles that will be measured in this study. These two approaches can also be used to categorize teachers' technology approaches to learning in the classroom. Technology applications used by students in the classroom include: CAI, ACOT, integrated learning systems, simulations, tutorial and tool applications. These different applications have provided a way to categorize applications based on low-level and high-level process. For example, CAI programs provided remedial drill and practice programs for students whereas word processors, spreadsheets, e-mail applications and

Internet used to search and interpret information is utilized for high-level use.

Makrakis (1988; Makrakis and Makrakis 2012) developed a model shown in Figure 1 that has been a widely used scale that measures levels of learning interaction from low to high levels. Scott et al. (1992) used the same model and applied it to learning interactions on computers in the classroom. They stated that "Makrakis proposed a schema of the relation between interaction and cognition that provides a useful index of the various 'modes' of computer-assisted teaching and learning in different parts of the curriculum" (Scott et al. 1992: 204). As illustrated by the model, drill and practice, tutorials, instructional games and simulations are located at the lower-end of the spectrum; while problem solving, spreadsheet, word processing, and database management are on the high end of learning and cognitive thinking.

<table>
<tr><td colspan="8">Level of Learning/Computer Interaction
Low -- High</td></tr>
<tr><td>Drill and Practice</td><td>Tutorial</td><td>Instructional Games</td><td>Simulation</td><td>Problem Solving</td><td>Spreadsheet</td><td>Word Processing</td><td>Database Management</td></tr>
<tr><td colspan="8">Low -- High
Level of Cognitive/Mental Thinking</td></tr>
</table>

(Scott, Cole, & Engel, 1992, p. 204)

Figure 1: Makrakis Theoretical Model of Learning Interaction

It is generally accepted in the field that computer programs such as CAI focus on basic learning objectives through drill and practice traditional teaching programs which reinforces low-level or remedial skills. Comparatively, individual and/or group problem solving applications use constructivist forms of teaching and support higher-order learning for students to process and critically think of the information they are receiving (Cognition and Technology Group at Vanderbilt 1996; McCaughtry 2005). This study will utilize Makrakis theoretical model of learning interaction and measuring computer use in schools to interpret student and teacher self-reported computer usage.

Summary

This theoretical framework provides both the sociological and educational significance of the role of technology to bolster student achievement. Two sets of issues are considered: what is important to sociologists and what is important to educational policy makers and to educational technologists. From the sociological perspective, in order to explain the social phenomena and understand the effects of educational technology and the perceived outcome to student achievement, examining individuals is not sufficient; rather, examining how students operate in specific settings, and how those settings form and restrict their outcomes provides a more sufficient examination. The importance is to focus on the social effects of educational technology to understand the interaction and relationship that exists between groups of individuals (i.e. administrators, teachers, parents on the students), educational organizations and social movements. Sociologically, the significance pertains to understanding how educational technology affects the organization of education as social institutions, schools and classes to promote equality and improve student achievement and addressing how certain groups (i.e. low-income and minority students) intersect with the various types of educational technology that is or is not used within schools. Lastly, the sociological significance is to determine the long-term impacts of educational technology on education as a social institution.

From the educational perspective, there isn't a unified accepted approach to how to use educational technology in the classroom for effective learning. Instead, there are theories that can provide descriptive ways to explain and account for students' learning experiences and outcomes. TPACK is one of the many theories that provides a framework to explain how teachers can use their pedagogical, content and technology knowledge to contribute to the students' math learning experience. This educational theory contributes to the design of this dissertation by providing a multi-level approach to understanding the complex learning situations, particularly as it evaluates how educational technology and software can shape the learning situation at home and within the classroom. TPACK helps to create a framework to analyze the effectiveness of educational technology, learning and teaching materials within the system. The second educational theory provides a perspective of the culture and contextual learning situations of the student at the school, at home and within the community that affect student outcomes. Together these theories provide the researcher with informed designs of systems and materials, and creates a framework to interpret the ways in which learning technologies impact students' experiences and outcomes.

Thus, incorporating the sociological perspective of the institution, organization, social change/movements, culture and demographic of the students helps to guide this research. The focus for this chapter is on both sociological and educational theories, the models and the instantiations within the systems. The next chapter reviews empirical evidence linked to these theoretical perspectives.

Chapter Three reviews the relevant empirical literature by first addressing the impacts of historical discrimination and segregation in the education system, which has led to the current day achievement gaps between demographic groups. Particularly, the literature focuses on the impact of U.S. court cases, policies and social movements to help decrease the achievement gaps between minorities and their peers. Despite the efforts of these adaptations, education continues to culturally reproduce inequalities in schools and within communities, creating a cycle of generational achievement gaps within minority and low-income communities. Next, the literature review illustrates how our public education system has focused on technology as a new mechanism to shape social and academic improvement despite demographic challenges. Particularly how infusing technology into the home, schools and within the classroom can potentially improve student achievement.

CHAPTER THREE: REVIEW OF RELEVANT EMPIRICAL LITERATURE

Achievement gaps between disadvantaged students (i.e. minorities and low-SES) continues to be an issue in the U.S. Research has suggested that in order to narrow these gaps, a series of changes must occur at the home, school and within the classroom. Over arching factors include the historical barriers of educational institutions, the bureaucracy of educational organizations and the social changes that have effected schools in disadvantaged communities. Within the classroom, the literature suggests that by increasing teacher quality, lowering student-to-teacher ratio's in disadvantaged communities, and having more one-to-one instructional guidance can narrow the achievement gaps (Peske and Haycock 2006). Since it is unlikely that most classrooms can support this type of individualized instructional-based learning, it has been suggested that technology may be a way to fill this void as effective technology integration could provide one-to-one tutoring, higher-order learning and increased group collaborative projects (Informational Technology Advisory Committee , 2001:6). McDonald (2009) stated that "using IT to personalize learning enables and empowers young people to pursue their own knowledge...by redesigning schools to incorporate new technologies, we can dramatically increase the personalization of American education with little marginal increase in labor costs." Evidence has illustrated that technology can potentially promote student learning and improve student achievement, and thus decrease achievement gaps

(Edwards 2003; Swain and Pearson 2003).

This literature review provides an investigation of the historical complexity of the achievement gap, focusing on social and political movements to narrow the gap between disadvantaged students and their peers. Next, this literature review explores how technology has evolved in classrooms since the 1970s to support student learning, specifically focusing on the emergence of the first and second digital divides in homes and in classrooms. The last two sections explore the home and school environments, investigating how technology access, usage and teachers' computer competency affect student outcomes.

Understanding the Academic Achievement Gaps

The purpose of the American education system is to provide individuals with the opportunity to participate in our society, to cultivate skills for the workforce and global marketplace, to establish critical thinkers, and to teach cultural literacy (Wenglinsky 2004). Public schools offer a free education for all to establish an equal path for opportunity for individuals to succeed in life. Despite the noble efforts of the educational system, the United States has had a long history of academic achievement gaps between minorities and their white peers, and based on socio-economic-status (SES). The achievement gap or "the gap" is defined as "the persistent presence of different average achievement levels for racial or low-income groups" (Meyer et al. 2002), and specifically for this study the differences between minorities and whites as well as low-income and middle/upper-income communities.

Hedges and Nowell (1999) reported that the test score gap on the National

Assessment of Educational Progress (NAEP) narrowed considerably between 1970 to 1990. However, after the mid-1990s, the gap has widened at a considerable rate (Waks 2005). As of 2013, research shows persistent gaps between demographic groups. At the age of 18, the average black student is roughly four years behind their white peers in overall academic outcomes. Thernstrom and Thernstrom (2003) found that black students graduate unable to even do simple mathematical computations. Furthermore, black and low-income students often score 50 percent below their white peers on standardized exams (U.S. Department of Education 2014). Achievement gaps are still a persistent issue in the U.S., and as the population of minority and low-income student increases these problems are expected to grow (U.S. Census Bureau 2014).

An array of researchers have attempted to identify the reasons behind the achievement gap in order to provide solutions to the issues. For purposes of this dissertation, I focus on two major contributions in the field. First, historically, the gap has been tied to issues with institutional and organizational segregation in the educational system, and attempts from the U.S. government to desegregate schools. Second, beginning with the1960s social movements. reports on achievement gaps focused on issues related to historical segregation, poverty concerns and other attributes that contributed to the achievement gap between black and white students, and those in low-income communities. These reports forced politicians to create new governmental policies to improve student achievement. Each of these concepts is further explained in the following sections.

Setting the Stage: Historical Segregation.

The difficulties surrounding segregation have always been focused on the issues and struggles of the "southern states;" however, it's more than that - it's about the historical occurrences that have led to modern multi-racial problems with deepening roots in poverty and racial discrimination. The strong connection between economic deprivation and minorities, also known as double segregation, continues to face ongoing challenges of substandard health facilities, poor housing, impoverished schools and a generational cycle of economic deprivation.

In this section, *Setting the Stage: Historical Segregation*, I examine the changing nature of segregation in the U.S. since the late 1800s brining the reader up to present day issues related to segregation. Additionally, this section provides a brief historical account of the legislation passed by the U.S. Congress in reference to the segregation of minorities since the late 1800's, exploring the connection between segregation by race, poverty and the unequal opportunities it has created for these groups. Furthermore, the goal of this section is to provide some clarity on the mechanisms of educational inequality by investigating the historical issues of segregation of schools as it pertains to minorities and those living in poverty. Investigations will explore how high-poverty and urban school districts have been systematically unequal over the last century, causing differences in academic achievement of minorities.

Segregation Before the 1960s: The Reconstruction Act of 1867, the Fifteenth Amendment, and the 1875 Civil Rights Act forbid racial segregation in accommodations assuring blacks certain privileges that they did not have previously. Despite these promises, democratic idealism (i.e. progressivism) ensured the collapse of the Reconstruction era and supported the wide passage of Jim Crow segregation laws across the south, allowing public spaces to continue to be segregated (Wilson 2009).

Jim Crow laws provided legal grounds to encourage economic, religious, political and educational institutions to promote inequalities and to ensure black suppression. Economic institutions in the south, specifically supported by white farmers objected to blacks having a voice, particularly if they were challenging their employers (Wilson 1978). Black labor workers were segregated into specific jobs with their identities being shaped by the lack of political or legal privileges, the inability to join labor unions and through acts of violence should the worker not obey. The plantation economy in the south continue to perpetuate a "system of slavery, severely restricting black vertical and horizontal mobility" (1978:24), and sustaining a powerful dynamic of control and suppression.

Other advocates of the Jim Crow laws, which supported a racial caste-system included many Christian ministers and theologians who taught that God supported racial segregation, and reinforced anti-black stereotypes. In addition to religious institutions, many politically supported organized movements (i.e., the Ku Klux Klan) resorted to violence to instill fear in blacks and to ensure they did not vote, speak against equality or attend schools. These major social institutions (economic, religious and political) demonstrated their endorsement for the continued oppression of blacks, providing rationalization as to why whites were superior to blacks.

Segregation of blacks in the south was upheld by the U.S. Supreme Court decision of *Plessy v. Ferguson* in 1896, which provided a law to legitimize and sustain "separate but equal" standards in southern states, representing the institutionalization of the Jim Crow period. This decision mandated that blacks continue to be racially segregated in public spheres, including racially isolated schools. In theory, all groups were supposed to receive the same "equal" public services (i.e. hospitals, schools, etc); however, inevitably, financial funding, facilities, and resources for these public services were unequal. Schools that had a majority of blacks or low-income students had lower quality, less public funding, and worse outcomes (Garibaldi 1997). The *Brown v. Board of Education* and the Civil Rights Movement of the 1960s eventually ended all state and local laws requiring segregation.

The 1950s: The push to create a public school system in which all children had equal opportunity to obtain the knowledge to participate and succeed in life came to a head during the *Brown v. Board of Education* (U.S. Supreme Court 1954) Supreme Court case. The landmark case called attention to the consequences of segregated public school areas enforced by the *Plessy v. Ferguson* case, finding unequal civil rights and poverty conditions of segregated schools were possible reasons behind achievement gaps (States Impact on Federal Education Policy 2009). These disparities led to the 1954 *Brown* decision that required all public schools to be desegregated, with the goal to provide an equitable education for all students. The result of the *Brown* case concluded that public schools should become desegregated "with all deliberate speed."

However, desegregation did not happen overnight, and many areas in the south prevented black and low-income students from entering into white schools, despite the court decisions. For example, in 1957 Orval Faubus, the governor of Arkansas hired the National Guard to prevent black students from entering and attending Little Rock Central High School. President Eisenhower deployed federal troops to Little Rock to provide safety for the minority students, and to allow them to enter into the school. In a protest against Eisenhower and the *Brown* court case decision, the Little Rock school board cancelled the school year in 1959. This is only one example of many where segregated schools pushed back on the federal decisions to integrate minority students into predominately white schools.

Segregation was not only in the south; northern schools were also segregated, even after the *Brown* court decision. The cause of northern school seregation were not tied to segregation laws but were associated with neighborhood residential segregation patterns, particularly in urban and large city areas. Residential segregation in the north, also called *de facto segregation*, had a particularly negative effect on the educational system. Since students typically attend schools that are within their districts, if their neighborhood school district was all black or low-income, then the schools for these neighborhoods were constituted of those demographics.

The 1960s and 1970s: Throughout the 1960s and into the 1970s the federal court system attempted to reduce the residential segregation issues by busing urban-black students to suburban white schools. For example, in 1971 the Supreme Court decision of *Swann v. Charlotte-Mecklenburg Board of Education* found that busing minority and low-income students to better schools (i.e. white or middle-income) could potentially resolve some of the racial imbalances in low-income school districts. However, this fueled more racial tensions and opposition about the new programs, specifically between the suburban white and urban black families. White suburban parents were adamently opposed to the busing programs as they worried that their childrens safety was at risk, and that the quality of the education would be decreased to meet the needs of the incoming black students. On the other end, black parents and students often faced racial hostility, and wondered about the merits of this new program (Lukas 1985).

During this same time period, Lyndon Johnson's *Great Society* emphasized civil rights issues and poverty and the effects they have on educational opportunities (States Impact on Federal Education Policy 2009). Johnson's administration had several successful legislative actions that attempted to reduce the effects of segregation. First, *The Civil Rights Act* was signed in 1964, banning legal segregation in public spheres, particularly in education (Lee and Orfield 2007). Second, as part of the *Civil Rights Act*, Title VI was established prohibiting discrimination by government entities or schools receiving federal and state funding (Lee and Orfield 2007). Third, in 1964 the report of the *Compensatory Education for Cultural Deprivation* provided the most comprehensive national information for administrators and teachers to understand the community of children they were teaching. The national report presented a summary of the effects and potential solutions related to cultural deprivation and the consequences it had on educational processes and student outcomes in disadvantaged communities. The report made a series of recommendations which eventually helped to ensure that large city and urban school districts received additional financial assistance to support their educational systems (Bloom 1964). Fourth, in 1965 the *Elementary and Secondary Act* (ESEA) was established, and a major component of the act was *Title I* which allocated additional financial resources to school districts with a high percentage of students living in poverty. Finally, in the late 1960s, *Head Start* was created in order to support the early education of pre-school students living in poverty.

The 1980s: As outlined, the 60s and 70s focused on creating a more balanced educational system by mandating busing and federally funded programs in low-income or high-minority school districts. Between 1977 and 1980, President Carter's administration financially struggled to continue the programs established in the 60s and 70s and requested greater demands on accountability practices of the programs to ensure the funding was used properly to support educational achievement. This fostered new shifts in educational ideology, starting a new era of educational funding based on program evaluation and student assessments. In 1982-1983, the Reagan administration promoted the *Educational Consolidation and Improvement Act* (ECIA) which supported large-scale federal cuts to educational categorical aid programs by more than one billion dollars (a 15% cut) and shifted the responsibility of program aid back to the state and local government level (States Impact on Federal Education Policy 2009). In 1983, the Reagan administration commissioned the analysis and report *A Nation at Risk: The Imperative for Educational Reform* which analyzed state and national standardized tests, including NAEP, to illustrate that the achievement gap of middle and high school students was lower than it was in 1957. The analysis criticized public schools for providing and promoting equity and access over achievement scores and pushed for standardized exams to illustrate differences in educational outcomes. The Reagan administration “marked a new era in federal educational policy, an era in which equal educational opportunities would be measured not so much in terms of financial aid, special programs, or even racial desegregation but, rather, in terms of standardized tests” (States Impact on Federal Education Policy 2009)

Then in 1988, a widely cited study by Douglas Massey and Nancy Denton refuted the claims and educational ideology supported by the Reagan administration, citing that continued segregation was the reason behind achievement gaps (Douglas and Denton 1988). They concluded that five dimensions of residential segregation contributed to segregation and charged that standardized exams controlled by state and local governments were not the answer to lowering gaps. Those five dimensions include evenness, clustering, exposure, centralization and concentration. In sum these dimensions focus on the isolation and segregation of minorities, particularly in urban communities, which fostered educational inequalities in school districts. Massey and Denton found that residential segregation was typically due to financial constraints, and minorities clustered into cheaper more affordable housing, which has led to the formation of hyper-ghettoization. Findings from Massey and Denton’s report on racial clustering in the late 80s still hold true today. Data from the 2012 census found that 29 metropolitan areas displayed black-white hyper-segregation, with unequal funding, facilities and resources – all factors that contribute to racial and income differences on standardized exams (National Center for Education Statistics 2013; U.S. Census Bureau 2014)

The 1990s and Beyond: Accountability continued to be a predominant focus of the 1990s and into the 2000s. A shift occurred during the Bush administration to focus on school standards. *Goals 2000* was established, decreasing the role of the federal government in the educational agenda, and giving power to each state and school district to mandate and authorize their standards and goals for their students. In 2001, the *No Child Left Behind Act* (U.S. Department of Education 2001) attempted to re-establish a national educational agenda, guaranteeing federal assistance to advance student outcomes by improving accountability, assessments and standards [3].

Reports on the Achievement Gap.

In 1966, The Equality of Educational Opportunity Study (EEOS), or the *Coleman Report* (1966) was commissioned by the United States Department of Health, Education and Welfare to analyze the best strategies to reduce racial differences in educational opportunities. The main purpose of the report was to determine whether racial integration or compensatory education should be utilized moving forward to eliminate barriers that poverty and racial inequalities created (States Impact on Federal Education Policy 2009). Findings from the Coleman report revealed that neither racial integration or compensatory education would reduce the achievement gaps; however, Coleman found that the most significant contributing factor to student success was family background and socio-economic status (States Impact on Federal Education Policy 2009). Coleman argued that per-pupil expenditures, library size, and other school-quality related variables had little significance for student educational achievement, whereas out-of-school factors

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3. Common Core Standards is a "set of high-quality academic standards in mathematics and English language arts/literacy (ELA). These learning goals outline what a student should know and be able to do at the end of each grade" (Core Standards Organization, 2010)

(i.e. low-income neighborhoods, minority segregated schools, low parent education, etc.) accounted for two-thirds of the variance in student achievement.

Other research efforts have followed with varying conclusions, including *A Nation at Risk* (1983), an all-encompassing report released in 1983 that targeted poorly performing minority students and the under-qualified teachers who staffed their schools. *The Black-White Test Score Gap* (1998), reiterated some of the factors in the *Coleman Report* and expanded this list to include parenting practices, economic disparities, cultural influences, stereotype threats, and labeling and selection biases. *The Bell Curve* (1994) pointed to hereditary factors to explain the achievement gap, implying that African-Americans were intellectually inferior to whites. This book was highly controversial and critiques emerged on the validity of IQ and general intelligence testing, dismissing most of their findings.

Similar to the Coleman Report, Jeynes (2003) found home factors played an important role in student outcomes. Unlike Coleman, Jeynes focused on religion as a potential indicator for at-home factors that influence student achievement. The results indicated that parental religious commitment, had a positive impact on the academic outcomes of urban students. While Ferguson (2007) analysis attributed two-thirds of the achievement gap to home-related factors such as: intellectual lifestyles, parent educational levels and parent involvement with homework. Similar to Coleman, Ferguson's research found that school-related factors such as: funding, availability of resources, teacher preparation and competencies accounted for only a small proportion (one-third) of the achievement gap.

Research on institutions and organizations of the educational system found that minority and low-income students start school with fewer academic skills than their white or middle-income peers, and this intellectual gap persists within the school environment (Phillips et al. 1998b). In contrast, many educational-sociologists believe that minorities and low-income students come to the classroom with the same skills as their peers; however, the institution of school and teachers create and maintain achievement disparities between groups of individuals. For example, Good and Brophy (1997) and Dale (2001) argue that academic achievement is closely tied to the effectiveness, training and competency of teachers, finding that teachers in low-income or racially segregated schools are often less trained and less competent than teachers in middle and upper-income school districts. Valli and Buese (2007) found that teacher workloads, accountability, and deteriorated classroom pedagogy lowered the quality of teacher-student interaction and increased teacher stress after the *No Child Left Behind Act* (2001). These researchers suggest that institutional and organizational barriers in low-income school districts, restrict access to qualified and effective teachers. Without the essential in-classroom support, students in disadvantaged schools will continue to struggle behind their peers. Throughout the last three decades, social and political movements have attempted to rectify this situation by providing funding to promote equality.

Social and Political Movements to Improve Student Achievement.

Federal and state policy makers focus on improving student opportunities by providing financial resources and access to disadvantaged school districts. National and state resolutions have sought to increase per-pupil investments. The National Center for

Education Statistics (NCES) and the U.S. Department of Education (DoE) reported in 2011 that over the past 25 years, the U.S. has nearly doubled its per-pupil education investment; however, improvements in student achievement and performance between minorities and whites, and low-income vs higher income remain negligible (National Center for Education Statistics 2013).

Over the last two decades investments from government agencies, as well as public and private firms have attempted to help support school-based initiatives to improve student achievement. These interrelated movements for school improvement are centered around three major areas, where one leads to the next: *standards, teacher quality,* and *technology* (U.S. Department of Education 2007a). Examining each of these three social movements guides sociologists to identify and assess the impact social change in educational institutions and organizations can potentially facilitate equality in education.

Standards movements began with a series of reports starting in 1983 with *A Nation at Risk*, finding that our educational system was "producing a generation of mediocrities" (The National Commission on Excellence in Education 1983: 1). The report called for policy makers to raise the academic standards set in the 1970s, and increase the requirements of students in math reading and science. Southern state governors: Lamar Alexander, Richard Riley, and Bill Clinton, took the most aggressive approach to policy reform initiatives and led a nation wide summit starting in 1989 to formulate a series of standards and goals to be met nationally by 2000. The series of meetings from 1989-1994 led to *America 2000* which focused on standards and assessments that included: *content, performance*, and *assessments*.

Content standards are focused on the specific subject matter that students were supposed to learn and understand based on their grade level. It was implied that these required subject-specific content standards included all material that students needed to understand to move seamlessly into college. These standards were first operationalized in the *National Council of Teachers of Mathematics* (NCTM) standards in 1989. In order to improve the mathematics curriculum, NCTM focused on the root issues attributed to low math scores: a lack of standards and teacher quality. In order to address the lack of standards, in 1990 NCTM published the *Curriculum and Evaluation Standards for School Mathematics* framework which created five mathematics standards to be recognized nationally. Those standards included: number/operations, geometry, measurement, data analysis, and algebra/functions, and were used as the framework for the NAEP standardized assessment tool. Next, NCTM addressed the lack of teacher knowledge and inability to teach the appropriate curriculum and national standard by developing the 1991 *Professional Teaching Standards*.

Performance standards are focused on what the students are required to demonstrate proficiency in the content-subject area standards. For example, the content standard for geometric theorems is to have the knowledge and understanding of angles, and performance standards evaluate if the student can apply that knowledge to certain problems on an exam. Lastly, assessment standards are the actual standardized exams that test the students' ability to understand the content and apply it to the subject areas. Assessments provide framework that gives appropriate weight to different levels of ability, and what students should be able to perform based on age.

The culmination of the standards movement happened with the the passage of the reauthorization of the Elementary and Secondary Education Act (ESEA) in 2002, also known as the No Child Left Behind (NCLB). This was a federally funded program to establish financial assistance for disadvantaged students (i.e. Title I of the ESEA). During the Bush administration, NCLB provided legislation to provide funding for states to develop and improve standards and assessment plans in their educational systems. States were also given authority to determine if schools were meeting their standard of Adequate Yearly Progress (AYP). In order for schools to stay in compliance with NCLB they had to meet the accountable requirements; if found “failing” to meet the requirements, they would be issued sanctions against their school. NCLB requirements were: (1) By the year 2014 all students must be performing at a proficient level in math, reading, and science; (2) Each school, every year, must meet “adequate yearly progress,” at the necessary rate to reach 100 percent proficiency by 2014; and (3) Annual rate of progress is not only for the aggregate student enrollment per school, district, or state, but also holds within disaggregated groups, based on income, race, gender, English language ability, and special education status (States Impact on Federal Education Policy 2009).

The standards movement, was the first of the three school improvement movements discussed in this section. The standards movement helped pave the way for the next two movements: teacher quality and educational technology. These movements were focused on students equal opportunities to learn despite their disadvantaged circumstances. Many educational leaders, researchers and policy makers believed that improving teacher quality would improve the standards of the learning environment for the student. Others maintained that educational technology can be one of the most effective tools to strengthening schools and ensuring equality is maintained.

Teacher quality movements and affiliated policies have focused on increasing the standards needed for pre-service and in-service teachers. In response to the 1983 *Nation at Risk* report two reports followed: the Carnegie Forum on Education and the Economy (Carnegie Forum on Education and the Economy 1986) and the Holmes Group Report (1986); both focused on the low quality of teachers and reforms needed to improve the preparation of teachers. Various reports and proposals followed to increase the quality of teachers. In 1996, the National Commission on Teaching and America's Future (NCTAF) reported in *What Matters Most: Teaching for America's Future* (1996) the key problems to improving teaching quality and recommended that the U.S. Department of Education (1) reform pre-service and in-service teacher training requirements; (2) link standards for teachers to standards for students; (3) improve teacher recruitment so that each student has a qualified teacher; (4) restructure school incentives to reward good teachers and punish poor ones; and (5) reorganize schools to support effective teaching (2002: 3). Following the NCTAF *What Matters Most* report, the National Council for the Accreditation of Teacher Education (NCATE), the Interstate New Teacher Assessment for Support Consortium (INTASC) and the National Board on Professional Teaching Standards (NBPTS) integrated NCTAF requirements into the national accreditation standards for schools.

In addition, federal, state and local governments implemented programs and policies to increase teacher quality. At the federal level, the Clinton administration provided $4.6 billion to increase the number of teachers in schools in order to reduce class size. The administration also provided $564 million for professional development courses for teachers. The Bush administration consolidated the Clinton programs into one single block of grants and allowed states flexibility to allocate the funding as they saw fit. The Highly Qualified Teacher (HQT) program was initiated in 2001 as part of the NCLB act to set criteria required for teachers. Over $2.6 billion was provided to states to promote and create incentives for teachers entering into the workforce.

Technology movements and associated policies have been focused on spending billions of dollars to improve technology infrastructure, technical support, and professional development to develop the quality of technology in schools and to increase the quality of teachers' computer integration into the classroom.

Federal involvement with the educational technology movement started with the *Improving America's Schools Act* of 1994, which became the *Technology for Education Act* of 1994 which focused on improving student achievement through an increase in technology and access. The primary goal was:

> Sec. 3111: [T]echnology can produce far greater opportunites for all students to learn to high standards, promote efficiency and effectiveness in education, and help propel our Nation's School Systems into very immediate and dramatic reform without which our nation will not meet the National Education Goals by the target year 2000. (U.S. Department of Education 2003)

Shortly after, in 1996, the Clinton administration added to the policy and initiated The Technology Literacy Challenge Fund (TLCF) and the Technology Innovation

Challenge Grants (TICF). TLCF's primary goal was to fund technology infrastructures throughout school districts to improve student technology literacy. In order to accomplish this goal, the program offered $5 billion to states over five years. Additional five-year grants were given to states to promote the four goals of TICF: increase professional development of teachers to integrate technology into their classrooms; provide projects to increase student learning; enhance school technology infrastructures through the use of hardware access and connectivity; and digital content through the use of technology applications.

In addition to the federal government's increase in funding for technology initiatives, Congress passed the Telecommunications Act in 1996, which asked telecommunications corporations to give school districts financial support to have internet access in the classrooms.

The *Enhancing Education Through Technology Act* (EETT) is part of the NCLB Act of 2002 and reinforces the extensive goals formed by the *Elementary and Secondary Education Act* (ESEA) through the use of technology. EETT is the only federally funded program of the Department of Education to provide financial assistance to states to support student achievement by improving their use of technology in the classroom in high-poverty elementary and secondary schools. EETT distributes grants to State Educational Agencies (SEAs) based on the proportionate share of funding under Part A of Title I of the EETT program. SEAs then appropriate funds at the school district level based on formula and competitive grants focused on EETT's primary and secondary goals.

EETT's primary goal is to provide formula and competitive grants to states in order to improve student academic achievement through the use of technology in elementary and secondary schools. A secondary goal of EETT is to help all students become technologically literate by the end of the eighth grade and to integrate technology with teacher training and curriculum development to establish research-based instructional methods that can be widely implemented. Research previously conducted by the *The National Council of Teachers* supported the goals of EETT and reported that "technology is essential in teaching and learning mathematics and reading literacy; it influences what is being taught in the classroom and enhances students' learning." (National Council on Teacher Quality 2006: 17) However, many of the larger EETT program grants have supported increases in infrastructure, computers and software in the classroom; less funding has been given to teachers to effectively integrate the technology in the classroom.

In 2009, the Obama administration initiated the *Race to the Top* (RT3) program which has provided $4.3 billion in competitive grants to support education reform and technology innovation in the classroom. The program's goal was to turn around low-performing schools by building data systems that measure student success and inform teachers and administrators how they can improve their practices; by providing funding to the State Educational Technology Grants (ETG) to help bring technology into the classroom; and by providing funding to support the recruitment of highly qualified teachers, increase their professional development, and retain effective teachers.

In late 2013, both the House and the Senate began efforts to reauthorize the

Elementary and Secondary Education Act (ESEA), and to revisit the goals of the *Educational Technology* legislation. Currently, the Senate is focused on a separate, directly funded educational technology program that revamps the currently existing, but unfunded, *Enhancing Education Through Technology* (EETT) program while the House has only briefly mentioned technology programs. The Senate's bill calls for the *Achievement Through Technology and Innovation Act* (ATTAIN), which would provide substantial technology funding to support disadvantaged school districts. Specifically, school districts would have to reserve 60 percent of funding to implement technology tools, applications and other resources, and 40 percent for technology-focused professional development. Despite the vagueness of technology in the House bill, it does focus on professional development, including training for administrators and teachers in the use of technology to improve student learning. The debates between the House and Senate on this legislation is continuing.

Technology is not just about increasing the number of computers or having the latest software to teach math or reading literacy; it also includes how teachers utilize technology as an effective tool to support learning in the classroom. A policy report released in 1996 by the National Commission on Teaching and America's Future called *What Matters Most* found that workforce productivity increased in response to the intellectual demands set and technology was the leading factor for the major productivity gains (National Commission on Teaching and America's Future 1996). Thus, the belief was that by implementing technology into the schools, achievement gains would mimic the gains in the workforce.

In 1999, the Clinton administration initiated the Preparing Tomorrow's Teachers for Technology (PT3) which provided funding to higher education programs and school districts to provide technology training to pre-service and in-service teachers. The goal was to:

> create one or more programs that prepare prospective teachers to use advanced technology to prepare all students, including groups of students who are underrepresented in technology-related fields and groups of students who are economically disadvantaed to meet challenging state and local academic content standards. (U.S. Department of Education, 2004)

E-Learning: Putting a World-Class Education at the Fingertips of All Children (2000) and *Moving from Promise to Practice* (2001) focused on evaluating the goals of PT3. These reports found that disadvantaged school districts still needed:

- greater access to computers, internet and networks infrastructure;
- more support for pre-service and in-service teachers to be computer proficient and competent;
- training for students not only in how to use computers, but also in how to develop appropriate problem-solving skills using computers;
- digitization of more educational materials; and
- a systemic research and evaluation agenda on the application of technology to teaching and learning, including state and local evaluations of technology as well as the dissemination and concrete use of study results (Wenglinsky 2005: 22-23).

The Association of Mathematics Teacher Educators (AMTE) and the Association of English Teacher Educators (AOTE) reported that "mathematics and reading literacy teacher preparation programs must ensure that all mathematics and literacy teachers and teacher candidates have opportunities to acquire the knowledge and experience needed to incorporate technology in the context of teaching and learning mathematics and literacy" (Association of Mathematics Teacher Educators 2006). Niess (2005) found that there is a limited number of teachers that are proficient in utilizing technology to teach their subject matter. Furthermore, he states that "learning subject matter with technology is different from learning to teach that subject with technology" and finds that "how teachers learned their subject matter is not necessarily the way their students will need to be taught in the 21st century" (Niess 2005: 517).

Additionally, The National Council for Accreditation of Teacher Education (2007) has made ongoing efforts to increase the capacity and proficiency of teacher-preparation programs. The new Unit Standards has created guidelines for teacher-educational programs to support pre-service teachers' pedagogy and content standards; however, it does not incorporate standards for technology use in the classroom. In 2009, the *National Educational Technology Standards for Teachers* and *Students* (NET-S) developed in conjunction with the International Society of Technology in Education (ISTE) provide overall content and subject-specific standards; however, these did not update standards to address content or subject-specific standards to effectively support teachers and students use of technology for learning math (Niess et al. 2009). In order to enhance learning opportunities and improve student academic achievement through the use of technology, it is essential to prepare and equip teachers with skills to effectively integrate their pedagogy and content knowledge with technology in the classroom. Furthermore, teachers must incorporate technology into the math curriculum, emphasizing problem-solving applications, integrated media, and electronic networks to provide students with higher-order thinking skills (Niess et al. 2009).

The role of these three social movements (standards, teacher quality and technology) illustrates how educational institutions have reinforced the social commitment to the values and norms placed with the educational social structure. As those value systems shifted, new forms of standards were developed to support the continuous commitment to the established educational value system. As part of the change in standards, it was necessary to integrate teacher quality and technology in order to promote equality of educational opportunity. Federally mandated resources were organized in order to achieve the intended goals set by the national standards. This section outline the importance of educational social movements, illustrating how they materialized, organized, processed, grew, and made adaptations to promote equal opportunities.

Achievement Gaps Still Persist.

Despite the impact of the three policy movements (standards, teacher quality, and technology), reform-oriented math instruction, substantial increases in funding for public education in terms of technology infrastructure, and increases in home and classroom computer use the achievement gap has not improved at a significant rate. According to NAEP data reported from 1970 to 2011, minority students have improved their overall test scores in math and reading but the achievement gap persists where minorities trail significantly behind their white peers. NAEP scores indicate that the vast majority of disadvantaged students are not proficient in math, science or reading at the 4th, 8th or

11th grades. Jencks and Phillips (1998a) found that minority students scored 75 to 85 percent below whites on standardized tests. Thernstrom and Thernstrom (2003) found that nearly one-third of all low-income and minority students leave high school unable to read, write, or do simple mathematics. In 2013, NAEP reported that minority 12th graders score at roughly the same levels in reading and math as white *eighth* graders. Disparities between groups still exist, despite the increase in funding and new innovative approaches to public education.

Given the significant increase in financial resources provided to public education and the persistence of gaps, U.S. school reform initiatives should consider examining how the money is spent and the effects it has on student outcomes. At that point, discussions of school reform can incorporate an assessment of the current relation between inputs and outcomes and determine how to best allocate resources in specific contexts (Hedges and Greenwald 2006). From this, disadvantaged school systems can more effectively utilize inputs (i.e funding and resources) to increase student achievement and successfully minimize the achievement gaps. Instead of simply increasing funding for disadvantaged school systems, efforts to improve education should focus on the types of resource allocation within the classroom that is most effective. In light of the historical legacy of policy-making activity, I propose to examine how educational technology: access, frequency and usage at the home and within the classroom can promote positive student outcomes if used with constructivist approaches to learning.

Spread of Technology to Improve the Achievement Gap

This section provides an overview on the relationship between educational technology, the digital divide, disparities in the use of computers and technology and math student achievement. First, I review the historical technology policies that relate to school reform and student achievement, reviewing the relationship of early integration of technology into classrooms and the various reform efforts that have bolstered educational excellence.

Next, I examine a model developed by Hohlfeld, Ritzhaupt, Barron and Kemker (2008), which provides a visual diagram of the impacts of the first and second wave digital divide. The first wave of the digital divide also known as the ‘access divide’, focuses on the lack of equal access to computers and the internet within schools and homes. Hohlfeld et al.’s diagram illustrates the first wave of the digital divide as it affects the school infrastructure, particularly access to hardware, software, internet and support for technology. As technology became more affordable in the 2000s, schools were able to provide more equitable access to hardware and software and the first wave or “access divide” diminished substantially, which leads to the second wave. Hohlfeld et al. emphasized the second wave of the digital divide, also known as the ‘knowledge divide’. The diagram focuses the second digital drawing attention to how students and teachers use technology in the classroom, the skills they acquire, and the type of content they access (Warschauer 2008). In addition, the model will be extended to incorporate an examination and assessment of the effects of home technology access and usage as it pertains to student outcomes.

After examining the model and the effects of the digital divide, the next sub-section focuses on the disparities that exist in terms of demographic influences (i.e. race/ethnicity, income and parent education) on computer usage and student outcomes (DeBell and Chapman 2006). Research has illustrated that despite efforts to improve and empower students and teachers to effectively use technology, there continues to be a lack of quality technology usage and minority and low-income students continue to use technology in unproductive ways (Warschauer 2008). Students who are less likely to be exposed to computer use associated with high academic performance are those who are socially stratified in disadvantaged areas such as low-income, heavily minority, urban and large-city environments. These areas are influenced by theoretical frameworks on conflict theory that relate to various forms of racial and economic oppression, and societal privilege as a reason for the first and second waves of digital divide phenomenon (Carveth 2013).

The Evolution of Technology and the Digital Divide: From Access to Usage.

Since technology was first introduced into the learning environment, the federal government has supported the use of technology in schools. Starting in the 1970s, the federal government provided computer funding through federal Title I grants that supported drill and practice applications for mathematics and reading programs in elementary school (Jamison et al. 1974). In the 1980s the federal government supported the use of Logo - a programming language and computer tool that developed critical thinking skills for elementary students (Papert 1993). Also during the 80s Apple and IBM marketed low-cost personal computers. Schools bought the computers, loading them with Computer Aided Instruction (CAI), with the hopes it would enhance students' educational experience. For the most part, CAI utilized drill-and-practice modules which had students interacting solely with the computer, decreasing the time teachers spent on lecturing.

The Nation at Risk (1983) also bolstered the use of computer competency for students, and reported that technology skills were needed for the information-based skilled workforce of the 21st century. The first assessment of middle and high school students' computer competency was conducted in 1986 using the NAEP standardized exams. The assessment found that schools in disadvantaged areas that had low-income and/or high minority populations had limited access to computers and outdated programs.

In 1995, a report released by the Department of Commerce: *Falling Through the Net: A Survey of the Have-Nots in Rural and Urban America* first coined the term "digital divide." This report found that access to computers and the internet was not equally distributed across the country, and those in poorer segments had little opportunity to utilize technology in the classroom or at home. This stimulated the attention of researchers and policy makers to investigate differences within K-12 schools in the United States. Equitable access to hardware, software and infrastructure within schools and at home became the starting point for research and, the term "digital divide" was created to define technology gaps based on demographic factors. This term became an international concern due to the effect it had on educational opportunity (Saaris 2001; Eamon 2004).

It took nearly a decade before the federal government implemented a large-scale technology improvement plan to increase access to technology programs. The Clinton administration created the *Technology Literacy Challenge Fund*, which provided $2 billion dollars that gave schools the funding to purchase equipment, computers, software and teacher training programs. Congress also authorized a E-Rate program that provided affordable internet connections for schools. More recently, the U.S. Department of Education's technology plan "expands the concept of eLearning, offering students greater learning opportunities, through their access to online courses and learning resources available from school and at home" (U.S. Department of Education 2013: 25). The first wave of the digital divide was conceptualized as a difference between those who had access and those that did not (van Dijk 2005; van Dijk 2012). Thus, this conceptualization indicated that after the access gaps were closed the use of the internet would become homogeneous and equity in education would improve (Valkenburg 2004). Consequently, most policy initiatives have focused on increasing access and not on increasing how to utilize and integrate technology effectively.

As federal policy initiatives have increased funding to schools, the U.S. has experienced a rapid diffusion of technology and internet access over the last decade. According to the International Telecommunication Union (ITU) (International Telecommunication Union (ITU) 2014), the internet penetration across U.S. households is 86.75 percent. Even though opportunities to access computers and technology continues to vary, the first-wave of the digital divide has closed dramatically among disadvantaged groups over the last decade. With the first wave of the digital divide nearly closed, Eamon (2004) and Reid (2001) reported that further investigations should examine differences in information literacy, computer literacy, digital literacy and information technology literacy among teachers and students. This conceptual shift from material access to actual use has become part of major research agendas, and researchers have paid particular attention to differences in motivation, appropriate skills, cognitive ability and self-confidence (Bucy 2000). Of particular interest is how specific segments of society, specifically minorities and those in low-income areas have differences in types of usage. Thus, scholars have reconstructed the way they examine the notion of the digital divide by exploring the ways in which teachers and students use technology to support learning. The emergence of this second wave of digital inequality research is typically referred to as the “usage gap” (van Dijk 2005), “second-level digital divide” (Hargittai 1999) or the “emerging digital differentiation” (Valkenburg 2004).

A Conceptual Model to Understand the Effects of the Digital Divide.

When considered as a multi-dimensional phenomenon, the digital divide becomes a complex reality with many influential factors. These factors can be addressed using a model developed by Hohlfeld, Ritzhaupt, Barron and Kemker seen in Figure 2 (2008). The triangular figure represents the different levels of information and communication technologies (ICT) access, usage and the associated activities that contribute to student achievement and outcomes at the school and classroom level. To expand on this model, my dissertation will also add an additional layer, the effects of access and usage at the home as it is associated with student outcomes. Tying these together, this dissertation uses these concepts to understand the divide between people or groups and their skills, adoption, use and outcomes.

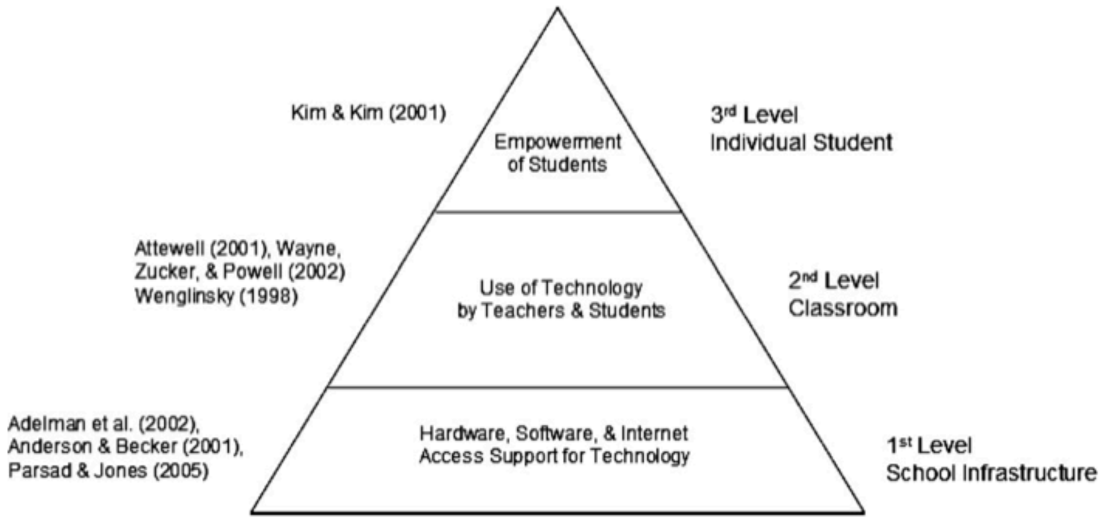

Fig. 1. Levels of digital divide in schools.

Figure 2: Levels of Digital Divide in Schools
Source: Hohlfeld et al. (2008)

At the first level, the digital divide focuses on equitable access to hardware, software, the Internet, and technology support within schools (Hohlfeld et al. 2008). This is the base of triangle model – access is designated as the largest percentage of research conducted (Parsad and Jones 2005; British Educational Communications and Technology Agency 2006; DeBell and Chapman 2006). This level is is often examined in terms of "student-to-computer ratios, teacher-to-computer ratios, Internet access types and the number of technical personnel within a school" (Hohlfeld et al. 2008: 1650). However, many additional studies also examine the digital divide by assessing student-to-computer ratios, and frequency of technology usage at the home (Becker 2001). For example, The

World Internet Project (Cole et al. 2012) found that those respondents who did not have access to PC-based Internet were largely from families with no college degree and had lower household incomes. Zickuhr and Smith (2012) found that those students who did not have a PC-based internet at home could not access or complete homework assignments; this then lowered their classroom grades. This dissertation expands on Hohlfeld et al.'s model to include the assessment of access to hardware, software, internet access and support for technology in the home.

The second level of the triangle represents the digital divide in terms of how frequently teachers and students utilize technology in the classroom, as well as the purpose they are using technology (Hohlfeld et al. 2008). Literature conducted at this level has illustrated considerable differences in how often teachers and students utilize educational technology in the classroom and at home (Wenglinsky 2000; Attewell 2001; Wayner et al. 2002). This level is measured by the purposes by which teachers use the software (i.e., analyzing information, constructing projects and assessing students' abilities), the different types of technology that are being used (i.e., tutorials, spreadsheets, or word processing), and finally how much the teacher is integrating the programs in their daily classroom curriculum.

The third level illustrates how technology can support students' academic achievement within the context of the classroom. Kim and Kim (2011) reinforced that the "key to bridge the digital divide is not access to or utilization of high-tech information devices or facilities but whether the user knows how to use them [ICT] for the betterment of their quality of life" (p. 85). This level focuses on how technology can empower the student to learn within the context of the school and the classroom. Hohlfeld et al. (2008) include the role and responsibility of the school to prepare teachers to integrate technology into their classrooms. Specifically, by providing them with professional development to increase their technology skills and “make good decisions so that they are capable of selecting and using the appropriate ICT for accomplishing valuable objectives in efficient ways” within the classroom (Hohlfeld et al. 2008). In order to measure this, data must review the level of student acquisition and identify how educators are weaving technology into the classroom to support their curriculum. This third level is contingent upon meeting the minimal requirements of the first (access) and second (frequency) digital resources.

Demographics and Measuring the Digital Divide.

These multiple divides occur as a sequence of hierarchy typologies, creating differences in access, duration, content, relevance, meaning and application that are associated with short and long-term student outcomes (Chen and Wellman 2004; Witte and Mannon 2010; van Dijk 2012). Each level creates a feedback loop that could potentially increase and institutionalize gaps associated with social inequalities, both affecting and reinforcing various divides (Bonfadelli 2002). Disparities exist in terms of demographic influences such as race, gender, parental education attainment, family or household type, family income, poverty status and metropolitan status and how it relates to computer usage and student outcomes (DeBell and Chapman 2006).

Literature on the *racial divide* focuses on how students from minority backgrounds tend to have less access to technology and utilize the technology in less productive ways. According to Child Trends (2014), in 2011 there still remains a gap in access to computers at home, with whites and Asian/Pacific Islander having more access (91 and 93 percent) than black or Hispanic (74 and 69 percent) students to computer technology. Additionally, whites and Asian/Pacific Islander are more likely to use the Internet at home (64 and 63 percent) compared to black and Hispanics (49 and 44 percent) students. More recently, The Pew Research Center recently released a study in 2014 on *African Americans and Technology Usage* (2014). They reported that roughly 74 percent of whites ages 18 and over had broadband internet access at home compared to 62 percent of blacks. These numbers were slightly lower compared to Child Trends numbers. However, the Pew Research Center reported nearly double what Child Trends released and found that nationally, 80 percent of blacks who were 18 and over used the internet compared to 87 percent of whites. Despite the inconsistencies between the reported numbers between Child Trends and the Pew Research Center, the common thread is that minorities continue to to have access and use the internet in the home. It is not clear in the literature as to the exact reasons behind the racial divide, but research points to a lack of exposure of minority students, the absence of culturally significant content, and the low priority for minority students to use technology for educational purposes (Nakarmura 2014).

Gender differences in access and usage of technology in schools has closed considerably; however, differences in perceptions, usage and pedagogical technology experiences have been found in terms of differences between females and males (Cooper 2006). In recent years, educational technology has been explored to understand if females are utilizing technology to learn in different ways (Kahveci 2010). Studies found that males had positive attitudes towards using technology for learning, while females reported having negative perceptions of using technology in the classroom (Kadijevich 2000; Li and Kirkup 2007). Hwang et al. (2009) found that when controlling for classroom access to technology, females are less likely to use computers than males, as they identified educational technology to be a male activity for learning. Similarly, Zhou and Xu (2007) discussed the complex interrelationship among technology, gender and and patterns of in-classroom technology usage. They found that gender matters in the process of technology adoption in the education setting, suggesting that females learned more efficiently in an environment that had "student-centered pedagogical approaches to teaching" with lecture based instruction (Zhou and Xu 2007: 148). Their research argued that females had lower confidence in their ability to use math software programs and were more inclined to learn how to use the software from other students or needing one-on-one assistance from their teachers. Comparatively, males had higher confidence and were more likely to teach themselves through trial and error on the math programs.

Research further suggests that gender stereotypes also played a role in how females used technology. Hwang et al. (2009), found that even though the male-female achievement gaps in math and science are closing, societal influences affected the ways females used technology. Females reported that "they were still dismissive about their high achievement and feigned clumsiness to retain a feminine image" (Hwang et al. 2009: 265). Additionally, Dhindsa and Shahrizal-Emran (2011) reported that female students in high school math believed in equality of both sexes in using technology activities; however, females found educational technology to learn is less enjoyable and reported using technology less frequently in and outside the classroom.

Scholars continue to address the question of how educational technology is used in the classroom in order to provide the best environment for females and males to effectively learning. Instructional strategies have been proposed to support the gender differences in learning styles (Hew and Brush 2007). Evidence suggests that males tend to have higher level of access to educational technology and tend to use more project-oriented math and science programs (Hew and Brush 2007). Other studies have found that males have more prior knowledge of computers and educational technology usage outside of the classroom, suggesting that while in the classroom they have a better understanding of how to effectively use technology.

Comprehensive research on the *socioeconomic-status or income* divides, has indicated that the knowledge gap can be predicted by the segment of society people attribute themselves to, as those that have more financial resources can benefit from an infusion of information. For example, Zillien and Hargittai (2009) found that a user's economic status related to the different categories of "capital-enhancing uses of the Internet" indicating that individuals in more privileged economic positions "reaped the benefits" of their online Internet usage more than those from lower socio-economic backgrounds. They suggest that this is consistent with the "Matthew effect" proposed by Merton, whereas the rich get richer by the use of digital media (Merton 1968). Those in privileged economic positions utilize the Internet to increase their resources by carrying out information-orientated activities and transactions online (i.e. stock prices, product information and price comparisons) to improve their social position. While their research suggests that those in lower-stratus positions tend to use the internet for reasons associated chat rooms, to a slighter degree read the news online.

In addition to this, other studies such as DeBell and Chapman (2006) and Bausell and Klemich (2007) reported that the type of technology usage also parallels with this, as general studies have demonstrated that those with lower socioeconomic status utilize technology for gaming, instead of gaining positive educational and learning experiences.

Overall what these varying demographic divides tells us about the broader discourse encompassing the knowledge divide is that inequalities are part of a larger more complex social phenomenon that will not disappear once access and usage become readily available. Even though the digital access divide has considerably declined, the digital experience between minorities, females, and those in lower-economic stratus continues to have widespread effects on the type of usage and knowledge they are gaining from digital media.

The Home Environment

The literature on student achievement consistently has illustrated that the home environment plays a critical role in student outcomes. This section focuses first on overall home contextual factors that influence student achievement outcomes by reviewing key variables in the family processing model to include: socio-economic-status, parent educational levels, and the structure of the home environment (i.e. single parents). After reviewing how these variables directly influence student achievement, I then link home factors to technology access and technology usage in the home. Literature suggests that both technology access and usage is associated with students academic achievement, particularly in disadvantaged environments.

Home Contextual Influences on Student Achievement.

Family process models (Linver et al. 2002) have provided insight behind the minority achievement gaps, attributing home environmental factors as a leading cause to educational outcome inequalities. These uncontrolled environmental factors play a large role in the inequitable distribution of education in low-income, minority populated urban school districts. Instead of the educational system being a catalyst for socio-economic improvement and social change, it has been seen as a negative mechanism for social reproduction. Research has examined the importance of: socio-economic-status, family resources, parent involvement, household structures and parent education level as being lead indicators that affect the academic progress of students.

Socio-Economic-Status: Previous research has established that the social background of a student is directly linked to educational outcomes. Most research illustrates that there is a strong and positive relationship between lower socioeconomic status (SES) and lower student outcomes. Students from less privileged social backgrounds tend to score lower on average on standardized exams and are less likely to complete high school and attend higher education (Perie et al. 2005; Organization for Economic Co-operation and Development (OECD) 2010). For example, Coley (2002) reported that students with lower-SES backgrounds are less likely to be considered proficient on standardized exams in the areas of subtraction, ordinal sequencing, addition and math word problems. Palardy (2008) observed that students from high-poverty urban school districts were on average 3.3 grade levels behind students who attended higher-SES schools. Additionally, the U.S. Department of Education found that after controlling for students prior ability, on average SES background was a strong predictor of students' educational outcomes (National Center for Education Statistics 2009).

In addition to this, research literature examined the relationships between students living in poverty and the overall socio-economic composition of the school they attend (Palardy 2008; Perry and McConney 2010; Southworth 2010). On average, students in low-income families often attend schools that are underfunded and have a lack of school resources, which could attribute to their lower outcomes. Willms (2010) extends this argument and suggested that the academic performance of students is more strongly associated with school SES than with family SES. He attributed the rational behind this to the inadequate funding of poorer school districts creating negative consequences to include: classrooms with insufficient materials, school supplies, technology, limited curriculum support, a lack of basic instructional materials and teacher access (Means et al. 1991). While the reasons behind the association between school SES and student achievement are not fully understood, it is likely that lower SES schools are in a disadvantaged position, and can not fully furnish a constructive and invigorating learning environment compared to higher SES schools (Wilms 2010).

Family Resources: Students living in low-income households have fewer home-based resources and more family stressors that affect their student achievement. Morgan, et al (2009) found that students living in low-SES households have a substantially lower academic skill level and develop at a slower pace. Their findings suggest that the home environment provides the initial setting for early childhood development. A lack of resources, such as books, computers or tutors, contributes to lower academic scores. Aikens and Barbarin (2008) also found that the home literacy environment, e.g., total books owned and frequency of parent-child reading contribute to a positive home learning environment.

Parent-Involvement: Students living in low-income households reported having lower parent involvement or at home-support systems. Parental involvement in their child's education has been shown to significantly influence a student's academic performance (Jeynes 2003). For example, a parent who is supportive of school activities, encourages school academics at home and is a positive role model who will greatly improve student educational outcomes, possibly reducing the effects of parents' educational attainment, race and poverty on achievement (Jeynes 2003; Eamon 2004). Coley (2002) observed that only 36 percent of parents living in the lowest-income quintile read to their children on a daily basis, compared to 62 percent of parents in the middle-income quintile. A qualitative study conducted by Fields-Smith (2005) found that middle-income families were 47 percent more likely to be involved with their child's education, compared to low-income families. Furthermore, teachers often had a positive view of middle class parents roles in their children's academics compared to low-income parents.

Another example is in Putnam's work on social capital. Putnam found parent involvement in education to be an important contributor to student success. Students attending private schools had a higher rate of parent engagement and community involvement in school activities (Putnam and Borko 2000). He found that children whose parents were actively involved in their educational achievement produced students who attained at higher levels of success.

Household Structures: Literature on the family process model also suggests that there is a strong relationship between single parent household structures and low student achievement. Findings illustrate that single parents often have more socioeconomic stress factors (e.g., higher rate of unemployment and more financial strain) which in turn effects the parent-child interactions (e.g., lower levels of warmth, nurturance and monitoring of children) (Ferguson 1991). The consequences of having a single-parent household often means children had less time with the parent, fewer parental-school interactions and less guidance on homework/studying. Students living in poverty with a single-parent often encounter unstable household's that lead to differences associated with inconsistent parenting or reduced supervision and control adversely affecting a child's potential to learn and develop. Thus, research has pointed to the consequences of fractured family structures and the significant impacts it has on the social and educational learning environment and the relationship it has on academic outcomes (Astone and McLanahan 1991; McLanahan and Sanefur 1994).

Similarly, Barton (2004) found that parents who were accessible to assist in their child's education often increased the child's achievement. The family structure aided the student's developmental and academic growth substantially. Based on data in 2000, Barton found that 75 percent of white students lived with both their parents while only 65 percent of Hispanics and 38 percent of blacks lived with both their parents. Barton concluded that minorities who are single parents are constantly dealing with the struggles of working 10 to 14 hours on average along with the requirements of family life. With the amount of hours these single parent are working, it is difficult for them to spend the time needed to support their children's educational growth and development. Furthermore, he concluded that having two parents in the same household likely gives the student more adult support on student academics.

Parent Education Level: A parent's educational background is a significant predictor of a child's behavioral and educational outcomes (Nagin and Tremblay 2001; Davis-Kean 2005). Children who reside with parents that model achievement-oriented belief systems (e.g., read often, encourage positive work ethics, have advanced degrees) are more likely to provide achievement oriented opportunities (e.g., register children for enrichment programs, have educational books, read frequently with their children, and plan educational trips), which in turn develops a child's belief system to pursue academics. Additionally, parents who have a higher level of educational background often have higher expectations for their children and encourage them to develop their own internal level of expectations.

Literature that focuses on the effects of parental educational backgrounds on child outcomes utilizes data from cross-sectional and/or longitudinal studies, tracking students from childhood into adolescent years. Studies conducted by Jencks and Phillips (1998) found a positive correlation between parental educational level of blacks and student achievement; when parental educational level increased, so did student achievement. Brooks-Gunn and Duncan (1997) conducted an analysis using large-scale developmental studies and found that maternal educational level directly correlated with children's intellectual outcomes, even when controlling for variables such as family income. Davis-Kean (2005) also found a statistically significant relationship to parent education level on European-American student standardized achievement scores. Conversely, Duncan and Magnuson (2005) found only a two percent increase in student achievement for every year of education above high school the parent holds, and concluded that only a two percent difference was not significant enough in order to conclude a direct relationship.

Conclusion: In sum, there is a contemporary need to cautiously reinvestigate the relationship that exist between home contextual issues such as: socio-economic-status, family resources, parent involvement, household structures and parent education level and the academic progress of students. With emphasis on approaching the analysis with an integrated approach incorporating the indirect and direct impacts on race/ethnicity, gender, SES, and parent educational level. Furthermore, there appears to be a gap in the research in terms of how current theories consider home contextual affects and the direct impact it has on technology access and usage. During the process of examining this relationship, it is important to consider the principles of reciprocal causation; whereas there co-exists bi-directional influences among the various demographic factors which interact across time in order to produce a specific student outcome. The next section explores how disadvantaged students (i.e. those in low SES and minority homes) continue to have less access to important resources such as technology and the Internet in their home or community; which has had negative consequences on student outcomes in school.

Home Technology Access.

Home technology access to various types of digital media (i.e. phone, internet, and tablets) are on the rise for children across the United States. Despite the increase in access, data illustrates that education, geographical location, and income differences can create and cause digital divides. More specifically, people living in rural, economically disadvantaged, or poor-urban areas are often not connected or underserved, creating disparities between those who are connected and those that are not. Fairlie (2005) and Education Week (2011) found that there were larger differences in home access compared to school access; specifically differences were seen in key demographic predictors of ethnicity, parent education background, and income.

In 2009, The Kaiser Family Foundation (KFF) conducted a national survey of students between the ages of 8 and 18 years old, and found that 94 percent of whites compared to 89 percent of blacks and 92 percent of Hispanics have access to computers in their home (Rideout et al. 2010). Parental education levels also showed some substantial differences in access, while 91 percent of parents with a college degree had internet and computer access at home compared to 74 percent of children whose parents who only had a high school diploma.

In November 2011, the U.S. Department of Commerce used data from the Census Bureau's Current Population Survey (CPS) School Enrollment and Internet Use Supplement and wrote a report entitled *Exploring the Digital Nation: Computer and Internet Use at Home* (also referred to as NTIA) (2011). The report suggests that there is steady progress towards closing the home internet and computer access divide, particularly in minority and low-income households; however, gaps in access remain present with disadvantaged populations.

Similar to the KFF findings, the NTIA report found that those families from minority backgrounds, with lower education attainment, and lower-SES lagged behind the national average in computer access and broadband adoption. As illustrated earlier in the section on *Spreading Technology*, differences on access to computers and broadband Internet was found by race/ethnicity. Although KFF's finding were not as dramatic as other research, it was still substantially troubling. KFF's report found that while access to a computer by race vary from 80 percent for whites, to 64.9 percent for blacks and 66.6 percent for Hispanics; and access to internet use vary from 74.9 percent of whites compared to 57.8 percent of blacks and 59.1 percent of Hispanics. Educational attainment also had varying access levels, only 18.5 percent of parents with an elementary education had access to computers and the internet compared to 84.1 percent of parents with at least a bachelors degree. Income played another key role as computer access varied from 24.6 percent of households with an income between $5,000 to $10,000 per year to 95.5 percent for households earning over $150,000. Additionally, the report found that when holding constant certain household characteristics (i.e. race, education, income, etc.) broadband and computer access disparities decreased. This illustrates that gaps in access are specific to demographic attributes, and those who are disadvantaged groups (i.e. minority, less education, and lower-income) are less likely to have access.

Studies conducted by Fairlie (2007) and Fox and Livingston (2007) both reported in their studies access to the Internet and up-to-date technology was also due to a language divide. He found that 13.1 percent of “Spanish only” speaking parents had home Internet access compared with 40.1 percent among English-Speaking Latinos. Even when holding constant education, family income, immigrant status, and other demographic factors this access divide continued to be statistically significant.

These studies focused on access as a binary division between those students who have (or do not have) access; however, Warschauer and Matuchniak (2010) report that there in fact different levels of access related to the speed of internet, the type of computers they have access to, and the type of technology support at the home. For example, Margolis et al. (2008) and Barron et al. (2009) found that students’ computer mastery was dependent on the level of knowledge and support they had from their peers and family members. In their study, they found that students whose parents were immigrants or were from homes that were considered low-income tended to have lower digital media understanding and often could not assist with online-homework help. Additionally, households and neighborhoods that had poorer conditions often had less access to broadband internet, and a higher amount of out-dated computer technology.

Another study conducted in Philadephia examined students computer access and usage at city public libraries, and found that children in low-income communities relied heavily on free access to library computers (Neuman and Celano 2006). Children who utilized these computers typically did not have a parent present to mentor or monitor their computer usage, and often spent a significant amount of time waiting for access. When these students gained access, they typically played computer-based games with little textual content, thus displacing their reading, as game-based technology provides little development for educational progress. Comparatively, Neuman and Celano found that children from middle-income neighborhoods had parents who “carefully orchestrated children’s activities on the computer, much as they did with books” (Neuman and Celano 2006: 193). As a result, these students spent more time on print-based computer applications that averaged 11 lines of print per application, compared to 3.9 lines for students from low-income neighborhoods whose parents were not monitoring them. Thus, students in middle-income communities had more exposure to reading, comprehension and developing their critical thinking skills compared to those students playing game based technology.

These studies illustrate that demographics play a key role in determining a student’s ability to access the internet and have updated computer technology in their homes. Findings from research illustrate that students from low-income, less educated, minority and/or non-English speaking families are less likely to have Internet or computer access compared to students from higher income, white families. Home access is an important variable to consider when investigating technology as it relates to student achievement. To expand on this it is important to examine the ways in which students use the computers at home for educational purposes.

Home Technology Usage.

Disadvantaged groups continue to lag behind their peers when it comes to having access to the Internet and computer technology at home; despite this black and Hispanic youth spend more time than their white peers online per day. For example, KFF’s 2009 results of 8 to 18-year olds found that on average Hispanics spent the most time on the computer at about 109 minutes, compared to blacks at 84 minutes, and Whites at 77 minutes. Since minorities tend to be on the computer more frequently than their peers, researchers have investigated the programs minorities are using during their online time.

For example, Rideout et al. (2010) found that minorities also spend more time watching TV, playing video games and watching movies compared to their white peers. Similarly, Lenhart et al (2008) found the minority teens also spend more time on their cell phones, texting and making phone calls compared to whites. Ito et al. (2010) conducted an in-depth set of interviews and observations of middle and high school students use of digital media at the students home. Their findings determined that students primarily used home computers for *friendship-driven* and *interest-driven* purposes.

Students who used the computer for *friendship-driven* practices typically used technology to socialize and ‘hang-out’ with friends using social network sites such as Facebook, and Skype. Socializing online included activities that were associated with uploading/downloading music, videos, or pictures; updating statuses, profiles, writing on friends’ boards and/or blogging about events; chatting directly with friends in real time; or playing games such as Candy Crush. Computer use for friendship-driven practices is utilized by all students; however, minorities tend to use it more than whites. Furthermore, Rideout et al. (2010) found that blacks and Hispanic spent more time on social medial network sites such as Twitter than Whites.

Whereas, *interest-driven* practices are associated with specialized activities of interest or niche identities which drives the motivation for specific types of game playing, sharing of media and communicating in a more creative and adventurous manner. Home use of technology in this manner required a more sophisticated user to engage with new forms of media in a collaborative and deeper way, often requiring participation with people from around the world. Those individuals who participated in interest-driven home computer usage did so either by participating in one of two stages: *messing around* or *geeking out*.

The first stage of interest-driven practices, Ito et al. defined as '*messing around*'. Students used technology in this way to search for information online and to "begin to take an interest in and focus on the workings and content of the technology and media themselves, tinkering, exploring, and extending their understanding" (Ito et al. 2010: 20). A student moves into the second stage or '*geeking out*' when they have "an intense commitment to or engagement with media or technology, often one particular media property, genre, or type of technology" and "learning to navigate esoteric domains of knowledge and practice and participating in communities that traffic in these forms of expertise" (Ito et al. 2010: 28-29).

Two empirical researchers Gee (2003; Gee 2004) and Jenkins (2009) focused their research on students who engage in interest-driven '*geeking-out*' activities. They found that students who use technology to create, and develop new content are provided with a vital learning experience not offered in schools. However, Ito found that only a small amount of students have access to technology and social resources that can help them participate in '*geeking-out*' activities, providing a rationale as to why most students stay in the '*messing around*' stages of home computer technology use.

Ito's (2010) study does not stipulate which demographic groups use home technology for either stages (*messing around* or *geeking out)*; however, other studies focus on how different groups use computers at the home. For example, Attewell and Winston (2003) conducted a research project where they observed and interviewed two different groups of middle school students who were between 11 and 14. The first group they studied were students from poor and working-class families and consisted primarily of African Americans and Latino students. These students attended the local public schools, and a majority of them scored below grade level in reading. The other group were from affluent families, and the students attended private schools. The study found that students from wealthier families primarily used the computer at home for interest-driven activities, and were more inclined to use the computer for academic enhanced activities. Students from lower-SES participated in home computer use in the most basic levels, typically visiting sites that required limited reading and writing skills (pg. 117-119).

Similar to these findings, DeBell and Chapman (2006) found that a majority of white and high-income students in grades pre-K to 12 used the computer at home for e-mails, multimedia, word processing, spreadsheets and other educational learning capacities. Compared to low-income, and non-English speaking families where students focused their time on games or websites that didn't require critical thinking, or a high level of reading comprehension. Barron et al. (2010) conducted a study in a California community and found that students in high-SES communities in southern California were more likely to have greater home access to more sophisticated digital tools (scanners, iPads, digital cameras), and were more likely to understand how to utilize the devices since they had greater exposure.

Home Technology Usage and Student Achievement.

A number of research studies have found a positive relationship between students' use of computer technology at home and their achievement in the classroom (Attewell and Battle 1999; Wenglinsky 2002; Fairlie 2005; Bebell and Kay 2010; Shapley et al. 2010). According to Shapley et al's (2010) research of a technology immersion model in 21 Texas schools, there was a positive relationship between home technology use and student achievement on Texas standardized exams. There is also evidence that students with access to laptops, internet and computer software at home transition more easily to technology-rich classroom environments, specifically navigating educational-software products more easily in the classroom (Ching et al. 2005).

Research also points to varying effects of home computer usage and student achievement based on subgroup populations. Attewell and Battles (1999) analyzed National Education Longitudinal study of 1988 also referred to as NELS:88 The National Center for Education Statistics, National Education Longitudinal Study of 1988 (1988) found that minorities' home computer usage had a smaller effect on student achievement compared to their white peers. Furthermore, they found a strong statistical relationship between households that were in middle and higher socio-economic groups with a home computer and higher scores on on math standardized exams.

Other studies suggested that the purposes for home computer use was for recreational purposes, instead of educational. Fairlie (2005) found that students frequently used computers for a variety of purposes, to include: playing games, using internet search platforms, and using email; and were less likely to utilize the computer for homework or other educational purposes. Adding to this, Bebell and Kay (2010) found students spent a majority of their time utilizing the home computer for recreational purposes, which strongly correlated with a negative effect on math achievement in middle and high school.

In contrast, O'Dwyer et al. (2008) found a negative correlational between home-recreational purposes and math student achievement. Particularly, students who spent the majority of their time playing non-educational games had lower achievement scores on number sense and operations, data analysis and statistics. Similarly, Vigdor and Ladd conducted a five-year study of North Carolina public schools and found that home computer technology usage had "modest but statistically significant and persistent negative impacts on student math and reading test scores"; and hypothesized that having universal access would "broaden, rather than narrow, math and reading achievements gaps" (Vigdor and Ladd 2010).

Home Environment Summary.

The home environment plays a critical role in the learning outcomes of students, affecting their interest, motivation and objectives. Home contextual issues such as socio-economic-status, family resources, parent involvement, household structures and parent education level have been found to be important indicators that affect the academic progress of students. In addition to these contextual issues, learning outcomes has also been affected by a students ability to access and use technology in the home. Home technology access has been a function of the type of infrastructure and hardware ownership in the house; home technology usage, however, deals specifically with the types of programs students utilize at home. Research has mixed results on the effects of access to and usage of digital learning resources and materials at the home and student outcomes.

The School Environment

Determining the most influential school characteristics that relate to student achievement continues to demand attention from researchers, educational practitioners, and policy makers. Research agendas have focused on what factors and processes in the educational school setting have the most influential outcomes on student achievement (Fouts 2000). Previous research has suggested that low-student achievement is commonly associated with schools that have: (1) segregation issues related to poverty and minority status, (2) limited access to resources, (3) resources that are utilized in ineffective ways, and (4) limited teacher competency. In this section, I illustrate how these characteristics contribute to lowering student achievement.

School Contextual Influences on Student Achievement.

This section provides a brief overview of school-contextual explanations for achievement gaps between low-income and minority students and their peers: continual school segregation and associated resource issues. Within the school environment, students are furnished with varying levels of access, resources and opportunities based on their schools circumstances. However, in disadvantaged communities such as urban school districts *segregation* and *resource* issues continue to prevail and have created educational disparities between demographic groups. This study examines how educational technology is limited in urban school districts due to school segregation and resource issues.

Urban Segregation Issues: By definition, urban school districts are located within large central cities and are often characterized by having the highest concentrations of poverty, greater racial and ethnic diversity, larger populations of linguistic diversity and more frequent rates of student mobility (Kincheloe 2010). These demographic attributes provide the framework for the social and economic inequalities of these students and provide the back drop for the challenges of segregation in urban school systems.

Gary Orfield's (2011) *The Civil Rights Project* further explains how segregation and poverty magnify the problems faced in urban educational systems:

> It is wrong to assume that segregation is irrelevant, and policies that ignore that fact simply punish the victims of segregation because they fail to take into account many of the causes of the inequality…Current policy built on [this assumption] cannot produce the desired results and may even compound the existing inequalities. (p. 4)

Segregation and poverty are not new issues addressed in urban school districts, but rather have been issues over the last century. Rumberger and Palardy (2005) found that historical contexts behind sociodemographic attributes (i.e. those living in poverty and/or disadvantaged minority groups) significantly impacted how urban schools were structured and their processes. During the 20th century, the impact of widespread urban decay had devastating effects on urban neighborhoods and subsequently the decline in schools (Anyon 1997). Banks were not allowed to loan financial resources to rehabilitate specific neighborhoods, and homes (also known as redlining) which facilitated the decline of buildings and homes in the inner-city. Due to this, many middle class families abandoned urban areas to move to the suburbs and businesses followed, leaving poor urban-families without resources or well-funded schools.

Adding to this, Greene and Anyon (2010) found that the declining property tax base in low-income neighborhoods created insufficient school funding which crippled the public education system. Without funding from taxes or federal investments, urban school districts lacked finances for school resources, advanced classes, small class sizes, or the ability to repair and restore their property. To support these findings, the Education Trust wrote *The Funding Gap: Low Income and Minority Students Receive Fewer Dollars* and found that urban school districts had fewer state and local dollars to spend compared to suburban areas. These school financial barriers continue to perpetuate the structural challenges of the urban community: restricted resources, poor infrastructures, and limited effective teachers to promote student outcomes (Kain et al. 2005; Kincheloe 2010).

School Resources: States, counties and districts differ greatly in their school conditions, resources to quality teachers and funding to support students. These differences are labeled "savage inequalities" in Jonathan Kozol's book *Savage inequalities: Children in America's Schools* (1991), which focuses on inequality in school resources around the United States. He compares public schools in several inner city neighborhoods to those in the cities' suburbs. He accounts how many inner-city schools were literally falling apart, plaster falling off the walls, bathrooms simply non-functional and the buildings infested with animals and bugs. On top of the dilapidated structure of the building, the schools were overcrowded, class sizes were large, and many classrooms were not in actual rooms but situated in places like the auditorium or wherever space was available. These schools did not compare to their suburban counterparts, where schools had continual building improvement programs, teacher resources, and infrastructure support.

Kozol's research found large discrepancies in school spending per pupil and the quality of instruction. For example, Kozol found that per pupil spending in the inner-city school district in Camden, NJ, was less than half the amount spent in the wealthier town of Princeton. In East St. Louis, IL, a school district where the majority of the residents are black and poor, basic human needs such as sewage, and functioning bathrooms were absent, window frames were cracked or broken, light bulbs were missing from hallways and classrooms, and textbooks were shared among 3-4 students. Comparatively, schools in the surrounding wealthier white suburbs had Olympic sized swimming pools, a plethora of foreign languages, AP classes, music programs, and other perks.

In addition to Kozol's research, Aikens and Barbarin (2008) provided statistical evidence that urban and large-city school conditions such as a lack of resources and poor teacher quality contribute more to SES differences in learning rates than family and home characteristics, arguing against the Coleman Reports findings (Coleman 1966).

Muijis et al. (2009) reported that urban and large-city schools in high-poverty communities experience higher turnover of the most qualified teachers, creating a less stable learning environment. In addition, math and science teachers' background, quality of pre-service instruction and training for the specific needs of low-income students is significantly correlated with students' academic outcomes (Gimbert et al. 2007). Schools located in high-poverty urban areas were more likely to have less stable and less qualified teachers. The National Council on Teacher Quality reported that “at least 75 percent of the students were low-income, there were three times as many uncertified or out-of field teacher in English, math and science class” (2009). The report went on to conclude that despite major claims about successful reforms (i.e. HQT and NCLB), highly impoverished schools continue to provide a weaker education. They argue that it is unrealistic to expect an urban or low-income school district to significantly improve their outcomes without dealing with the issues associated with poverty and an overall lack of resources.

Another factor that affects school resources is the financial funding differences seen between low-income school districts and middle- or upper-income districts. For example, in 2011 annual per-pupil expenditures in Philadelphia, PA, was $10,878; in nearby suburban Lower Merion Township, it was $21,110, or 95 percent higher than Philadelphia’s expenditure (U.S. Department of Education 2012). Student expenditures are not the only financial differences, teacher salaries are also related to location within a state. Dillon (2011) reported that teachers salaries in wealthier neighborhoods were up to 3 times more than low-income or urban neighborhoods across the nation. As a result of the differences in pay, teachers in low-income schools are often inexperienced, have fewer qualifications and a higher turnover rate. Students in poor and urban areas are shortchanged from equal opportunities in education; the schools they attend compound their problems and help ensure that the American ideal of equal opportunity for all remains just that – an ideal – rather than a reality.

School Technology Integration.

Since the 1960s affluent school districts with financial resources started to promote the integration of technological platforms in the classroom to promote learning opportunities and student outcomes (Norton and Resta 1986). In the early 1980s Computer Assisted Instruction (CAI) began entering into more classrooms, focusing on drill-and-practice, tutorials, and instructional games to teach learning objectives (Norton and Resta 1986). Meta-analysis studies using statistical applications measured the effectiveness of CAI to promote student achievement, and only found modest gains across all populations; however, they did not focus on differences found based on demographic variables (Kulik 1994). Burns and Bozeman (1981) found positive effects of CAI in the classroom for students who were considered low-performing, and no effects for medium-performing students. Driscoll (1990) found that certain student learning styles benefited from CAI, where other learning styles did not. Niemiec, et al. (1987) found positive effects from CAI, but only when teachers used it as an intervention technique for low-performing students. Critiques found that the contradiction of results from CAI studies varied by organization, researcher, methods, and clarity of reports (Babbie 2002).

In the late 1980s, Apple Computers of Tomorrow (ACOT), attempted to improve the usage of computer programs, moving away from the low-end programs that focused on drill-and-practice towards more high-end learning objectives focusing on higher-order thinking or critical thinking skills in math (i.e. problem solving strategies, database management). ACOT focused its efforts on software that promoted long-term projects, student-initiated work, and multiple learning resources. In addition to ACOT, new interactive software programs (e.g., Where in the World is Carmen Sandiego?) also became widely available. Most researchers agree that CAI models were utilized for drill and practice so students could learn basic skills and teachers could maintain traditional teaching practices; compared to tool applications and simulation programs that supported open-ended learning and constructivist teaching practices (Scott et al. 1992; Means 1993; Cognition and Technology Group at Vanderbilt 1996). The constructivist approaches assisted in learning interaction in schools and improved student achievement.

In the 1990s, the integration of the World Wide Web, new forms of word processing tools, and personal productivity applications (i.e. Microsoft Office) transformed the computer from a tutor to a viable tool for teacher and student use in the classroom (Kulik 2003). By 2002, the federal government had invested billions of dollars to increase access to these technology platforms in disadvantaged schools. With the growth of wireless technology and the affordability of computer laptops and Internet connectivity students and teachers had immediate access to computers in their own classrooms. While investments were made to improve access, software was being reshaped to provide more effective tools for student outcomes. For example, integrated learning systems (ILS) and adaptive software programs provided software focused on higher-order thinking programs (i.e., Kurzweil 3000, Co-Reader, and Write to Read) to develop math concepts.

Additionally, access and computer usage increased when full one-to-one programs were offered, providing teachers and students with a laptop or iPad to use at school and at home. In 2003 roughly 4 percent of all public school districts across the nation provided this program to their students and teachers in at least one-grade level (Bebell and Kay 2010). In 2008, this number increased to 27 percent of all public school districts in at least one grade level (Greaves and Hayes 2006). The Department of Education's *The Long Range Plan for Technology, 2006-2020* (2008) outlined the intention to implement one-to-one laptops across the nation, and provided guidance for states to implement it in their technology plans. States across the nation adopted these programs; however, research on the effectiveness has had different results.

School Technology Access.

Over the past two decades the research on access to technology in the school system has changed from focusing on physical accessibility to computers to socio-technical factors that affect how people access technology (Warschauer 2011). Since the early 2000s with the increase in government funding to support technology in public schools, steady gains have been achieved in equity in access. For this reason my dissertation has adopted the broader viewpoint on overarching socio-technical factors that either bolster or restrict access to computer technology in the school environment.

Between 1999 and 2006, NCES released five reports and two issue briefs on "Internet Access in U.S. Public Schools and Classrooms," representing results from 85,000 public schools across the nation. From 1998 to 2005 the report presented data on students per internet-connected instructional computer, and findings revealed that students from more diverse public schools (high minority or poverty rates) consistently had less access to technology. However, the gaps in technology access in public school areas has decreased substantially. For example, in 1998 students who attended a school with 50 percent or more minority enrollment had a ratio of 17.2 students to one internet-connected computer, compared to public schools with 6 percent minority enrollment of 10.1 students to one internet-connected computer. In 2005 that number decreased substantially, as the ratio for high minority schools was 4.1 students to 1 computer, and low minority schools 3.0 students to 1 computer. Similarly, in 1998 students who attended public schools with 75 percent or more of students enrolled in the free or reduced lunch programs (high-poverty schools) had a ratio of 16.8 students to 1 internet-connected, compared to low poverty at 10.1:1; while in 2005 the ratio was 4.0:1 in high-poverty schools compared to 3.8:1 in low-poverty.

In addition to access disparities based on minority enrollment and poverty level, school size and location (i.e., suburban or urban) were associated with differentials in the ratio of internet-connected computers to students (National Center for Education Statistics 2013). The most recent 2013 NCES Digest of Education Statistics reported that internet connected computers to students ratio was around 3:1 regardless of factors associated with race/ethnicity, poverty status and location of school. The decrease in gaps in access to technology has been attributed to the federal e-Rate program which provided about $2 billion per year for telecommunications and Internet access in public school programs.

Socio-technical factors that have supported educational inequality also have either supported or restrained the use of internet and computers in disadvantaged public schools. Warschauer, Knobel and Stone (2004) conducted a comparative study focusing on public school technology use based on the SES of the surrounding community. Their findings revealed that students who lived in high poverty communities, attending schools with 50 percent or more students on free/reduced lunch programs, had less stable administrative, teaching and IT-support staff. The instability of school-wide staff made it more difficult to accurately plan for technology integration programs in the classroom throughout the academic year. Whereas schools that had high-SES enrollment were more likely "to invest in professional development, hiring full-time technical support staff and developing lines of communication among teachers, office staff, media specialists, technical staff and administration that promoted robust digital networks." These schools tended to "encourage more widespread teacher use of new technologies" and promoted the best ways to effectively integrate technology as a constructivist tool for learning, while high-poverty schools "had achieved less success in creating the kinds of support networks that made technology workable" (pg. 581). Since teachers in high-poverty schools typically had less computer training, they were less competent in how to effectively integrate programs into the classroom environment. These teachers reported using the technology more frequently; however, they used it in didactic ways or to replace their daily lectures (pg. 582).

School Technology Usage and Student Achievement.

School-wide internet and computer integration programs continue to be assessed for the most effective ways to incorporate technology into the classroom to achieve positive outcomes. Studies examining the relationship between technology use and student achievement have mixed results (Kulik 2003). Becker (2000) and Wenglinsky (2005) are two of the most widely cited large-scale empirical research studies focusing on technology use and student achievement. There findings both reveal imbalances in how technology was used and the effects on student achievement when controlling for race and SES. Additional smaller case studies such as Warschauer (Warschauer et al. 2004; Grimes and Warschauer 2008; Warschauer 2011) found the approaches teachers utilized in classrooms could potentially affect student achievement.

Assessing the 1996, 1998, and 2000 NAEP, Wenglinksy (2005) examined national patterns of technology use among 6,627 grade 4 students, and 7,146 grade 8 students. When analyzing computer technology use, he divided the variables into two comprehensive categories: the application of computers for activities that focused on lower order skills such as drill and practice, and computers that were utilized to focus on higher order or critical thinking skills. Wenglinsky had two major findings in his analysis. First, Wenglinsky reported that for overall grade 4 and grade 8 math courses, simulation applications had a positive affect on test scores, compared to grade 8 drill and practice technology programs which had a negative affect (see Table 1 below). Secondly, findings from this study revealed that there were significant distinctions on computer classroom usage by race/ethnicity, and free or reduced lunch eligibility. He found that African-Americans used the computer for remedial drill and practice programs in math. Within this racial population, he also found those students were taught by teachers who had less professional development in technology use compared to white and Asian students. Asian grade 8 students were three times more likely than African-Americans to report that their teachers predominately used computers for simulation applications. However, his report does not take into account that grade 8 Asian students were four times more likely to take higher level math courses, where computer simulation applications could be easier to integrate into the classroom curriculum.

Table 1: The Relationship Between Technology Use and Student Achievement
Source: (Wenglinsky 2005)

Subject: Grade	Test Scores
Math: Fourth grade	
Frequency of school computer use	-0.06
Use: games	0.03
Student SES	0.59
Math: Eighth grade	
Frequency of school computer use	-0.06
Use: simulations/applications	0.04
Use: drill and practice	-0.06
Student SES	0.39

Becker and Riel conducted a nationwide study that surveyed 4,000 teachers who taught in public classrooms in grades 4 through 12, for all subjects. The teachers completed a 20-page questionnaire collecting data about: within-school informal interactions (i.e. informal discussions about technology, type of technology usage), beyond school contacts (i.e. professional development courses in technology by subject area), recent involvement in leadership activities (i.e. presenting at workshops on technology). Similar to Wenglinsky's math findings, Becker found differences in computer technology use based on school SES in all subject areas. In math and English classrooms, schools with higher poverty rates typically used computer software programs that were designed for drill and practice applications. In summary Becker and Riel found that,

> Computer use in low-SES schools often involved traditional practices and beliefs about student learning, whereas computer use in high-SES schools often reflected more constructivist and innovative teaching strategies. For example, teachers in low-SES schools were more likely than those in high-SES schools to use computers for "remediation of skills" and "mastering skills just taught" and to view computers as valuable for teaching students to work independently. In contrast, teachers in high-SES schools were more likely to use computers to teach students skills such as written expression, making presentations to an audience, and analyzing information. (Becker and Riel 2000: 55)

Wenglinsky and Beckers' large scale-studies suggest that school districts in high-SES neighborhoods use technology for more constructivist approaches which supports student achievement, whereas low-SES schools tend to ineffectively use technology for drill and practice programs. In addition to these widely cited large-scale studies, smaller-scale studies have suggested mixed results between the use of technology in instruction and student achievement in mathematics. Three recent studies conducted by Bebell and Kay (2010), Warschauer (Warschauer 2008; Warschauer 2010) and Pierce (2007) all suggest a positive relationship between technology and student achievement, while other studies have reported that there are no significant effects of technology integration and student achievement (Cuban 1986; Zhao et al. 2002; Isikal and Askar 2005; Dynarski et al. 2009u8230?; Bebell and Kay 2010). The remainder of this section reviews the inconsistent results in the literature.

Bebell and Kay (2010) found that the way technology is used in the classroom can produce positive and negative results on student achievement. They found a negative relationship between technology use and student achievement, when students use technology in school: 1). for math purposes, 2). solve math problems, 3). present information using computers, 4). class-related activities, and 5). communication. Whereas, there was a positive relationship between home technology and student use for: 1). multi-media use, 2). online communication with peers and teachers, and 3). recreational and social home use.

Similarly, Tienken and Maher (2008) conducted a small-scale research, examining grade 8 students in a New Jersey public school. They found that teachers implementing CAI in math class had lower student achievement on the TerraNova mathematics exam. They concluded the reason behind this is that those teachers who utilized CAI in class only used it for drill and practice programs, and concluded that lower-order use of computers likely had negative effects on student achievement. However, neither study considered the issues around demographic disparities and their relationship to technology use and student achievement.

Warschauer (2010) conducted a small scale study which also examined comparisons of high-SES and low-SES public school's computer technology use. Warschauer analyzed 20 public schools in Southern California; he reported similar differences in computer usage between students who attended low-SES vs. those that attended high-SES schools. He provided more clarity on the types of constructivist activity used in low-SES public schools and found that those students used “shallow as opposed to deep constructivist” approaches to technology (Scardamalia et al. 1994). *Shallow constructivist* approaches were those that focused on student-centered collaborative works environments but only required basic computer skills and had limited goals (Warschauer 2010). Students in high-SES schools utilized the computer more often for *deep constructivist approaches* which used computer applications or the Internet to achieve a deeper understanding or to expand their critical thinking skills in the content area. Warschauer’s analysis provided findings that indicated the types of computer integration could potentially affect student achievement based on income.

Pierce (2007) examined schools in Wake County, North Carolina, that implemented the *Technology Connections* (TC) program which was created to effectively integrate technology into the curriculum and classroom setting. Schools with this program had more computers, laptops, and support staff. Their findings revealed that there was no differences before, during or after the implementation of the program in overall student achievement. However, when assessing differences based on race, Pierce found some differences in student outcomes. Asian students attending schools with the program had higher scores on math tests compared to Asian students without the program. Conversely, she reported that the program had negative effects on black students, where the students with the program at their school scored lower on the multiple choice section when compared to non-TC schools.

Bebell and Kay (2010) analyzed five middle schools in Massachusetts that implemented the Berkshire Wireless Learning Initiative (BWLI), a one-to-one computer program that started in 2005. They reported that students who participated in the BWLI used technology more frequently and scored higher on mathematics standardized exams. Those students who did not participate in the BWLI program, but used technology the same amount of time had lower math scores. Similarly, Shapley et al. (2009) examined the Technology Immersion Pilot (TIP) program in 21 Texas schools. Shapley found that students in grade 7 and grade 8 who participated in the program had positive math outcomes on the Texas Assessment of Knowledge and Skills (TAKS), compared to those students who did not participate in the program. Additionally, Hunter and Greever-Rice (2007) evaluated the Enhancing Missouri's Instructional Networked Teaching Strategies (eMINTS), a program that equipped each classroom with a scanner, printer, digital camera, SMART Board, a teacher dedicated computer, and one computer for every two students. Their analysis found that students in classrooms with eMINTS program had higher scores on the Missouri Assessment Program (MAP) math standardized exams than students with non-EMINTS classrooms. These findings suggest that once technology improvement plans are implemented, they can increase overall student outcomes.

However, other reports find that technology improvement plans do not statistically improve student outcomes on standardized exams. Sclater et al. (2006) conducted a study in Quebec that examined the effects of one-to-one computers and student math achievement. Their study found no relationship between one-to-one technology initiatives and math student outcomes. Similarly, Richtel (2011) examined the effects of a $33 million financial investment to improve technology access and usage in Kyrene School Districts in Arizona. Despite the additional funding for the technology improvement plan to increase computer and instructional technology, there was no improvement on scores. Interestingly, while statewide average math scores improved from 2005-2008, Kyrene School Districts average scores remained stable.

Evidence suggests that technology implementation across school districts, and subgroups are likely inconsistent thus producing differences in test scores and achievement levels. In addition to these effects, of particular interest for this study is the overall role of the teacher to promote student learning. The last sections of this literature review draws attention to teachers' approaches to learning (i.e. didactic and constructivist), the application of these approaches to technology, and the success it has on student outcomes.

Teachers and the Classroom Environment

The ways that students use computers in the classroom is predominately determined by the teacher's pedagogical techniques, their computer competency, and the ways they integrate software into the curriculum. Argued in this dissertation project, technology research needs to be understood not just as an isolated event in the classroom or at home, but rather as a multi-layer phenomenon that has many working parts for successful outcomes. Computers and software tools perform a specific role, and teachers and students negotiate what and how this role is determined in the classroom. In order to understand the type of computer technology used in the classroom, this study turns to examining the current literature on the two approaches to teaching pedagogy: didactic and constructivist. The literature review examines the most relevant studies that illustrate the effects on pedagogical approaches, types of technology usage and student outcomes. Next, it is important to understand how teachers integrate technology into the classroom, through the role of *Technology-Pedagogy-Content-Knowledge* (TPACK). From this specific model, the study utilizes three specific areas: *Technology Content Knowledge* (TCK), *Technology Pedagogical Knowledge* (TPK), and *Technology Pedagogical Content Knowledge* (TPCK) as they apply to evaluating teachers' use of technology, their computer competency, and the relationship to student outcomes (National Council of Teachers of Mathematics 2014). Lastly, this section addresses teachers' technology competency and the effects on student outcomes.

Teachers Approaches to Pedagogy: Didactic and Constructivist Approaches.

As outlined earlier in the theoretical section, educational researchers find that there are two different types of pedagogies - didactic and constructivist. Each approach creates a different type of learning environment for the student, particularly when technology is involved. This next section explores how technology is used by didactic and constructivist approaches to learning.

Didactic Learning and Mathematics: Math classroom instruction has been historically based on the didactic approach of teacher-based lectures. When technology access became widely dispersed, teachers substituted previous traditional tools (i.e. blackboard) with modern technology tools (i.e. smart boards). Mathematics curriculum and student learning continued to be focused on a linear approach, from facts to analysis. Students who are taught using didactic technology approaches are provided the same type of software programs and are pushed forward through the curriculum at the same rate despite their individual abilities.

Stewart, Schifter and Selverian's (2010) study observed over 30 classrooms and found a majority of mathematics middle school teachers took 'traditional' approaches (i.e. didactic), with passive one-way teaching of math curriculum. They also found that teachers who used technology in the classroom typically taught with power point slides, replacing previous didactic approach of writing on the board or providing handouts. They also found that the internet was used for drill and practice games that foster similar didactic learning approaches. Furthermore, findings revealed that didactic approaches used through online learning environments have been shown to decrease student test scores on standardized exams by 7 percent compared to those using student-centered approaches.

Constructivist Learning and Mathematics: As described in the theoretical section, constructivist approaches to learning use basic skills and embed them into advanced "bigger picture" or higher order thinking instruction. Many researchers find that constructivist innovation is the notion that learning is an active and constructive process, and it rejects the idea of knowledge transmission models (Hickey et al. 2001). From this perspective, knowledge is actively constructed by the learner and knowledge construction is the process of making meaning through connection with prior knowledge and the real world applications (von Glaserfeld 1991). Adding to this, Boethel and Dimock (1999: 19) said that "knowledge was constructed by the learner through experiences and prior understanding" and that effective "learning should occur in contexts that were adaptive" to the student. Thus, constructivist approaches are centered on the learner's experience, focusing on where the student is at in terms of content knowledge. The 21st century open-ended technology learning environment is ideal for these conditions.

Researchers have found a statistical relationship between teachers who use constructivist approaches in middle and high school math classrooms and improving student outcomes. Newman, Marks and Gamoran (1996) found that classroom instruction that supported constructivist approaches to authentic learning would positively improve task performance in mathematics. Similarly, Applebee et al. (2003) reported that discussion-based instruction promoted student learning and positively affected overall student outcomes on standardized test scores. Teachers using constructivist approaches in the classroom incorporate their knowledge of the subject content, best practices, applicable methods, common misconceptions students, and connections to future learning (1993).

Using the constructivist approach, technology can be integrated into the classroom (regardless of subject) so that it is student-centered, open-ended and focused on higher-order thinking skills. Research has suggested that mathematics teachers who merged technology into constructivist learning environments, positively impacted overall student achievement. For example, Dilliberto et al. (2009) conducted a study on middle and high school math technology use, and found that integrating technology using constructivist learning approaches showed statistically positive effects on student math outcomes. He said that, "technology use in an engaged learning environment will not only allow students to be 'part of a future' but also is creating a world of lifelong learners" (Dilliberto et al. 2009: 24). Another study conducted by Judson (Judson 2006) reviewed the relationship between teachers' learning styles and their use of technology in the classroom. His results found that teachers who employed constructivist methods were more likely to integrate technology into the lessons through an open-ended, student centered approach and less likely to use drill and practice software programs. His research suggests that the constructivist use of technology positively influences a student's ability to process and learn math content. Applying constructivist methods, teachers were able to customize learning environments and this statistically improved student math scores.

Ginns, Norton and McRobbie (2005) studied the impact of redesigning a math and science curriculum for middle school students to integrate technology utilizing programs that supported constructivist approaches. They found that when the curriculum connected technology to students abilities and interests, students were more engaged and learned the materials at a faster rate. This combination of technology with learning math and science curriculum demonstrated a positive shift as students' test scores improved.

Cheun and Slavin's (2011) meta-analysis of 74 rigorous studies on K-12 mathematics computer applications found evidence that technology made small but positive effects on mathematics outcomes. Particularly, the greatest effects on math achievement occurred when computer-assisted instruction was individualized to a student's needs, and technology was used to supplement traditional math instruction. Similarly, Rakes et al (2010) conducted a meta-analysis of 82 studies; out of those, 15 were focused on technology based curricula (i.e. Cognitive Tutor), and 21 were studies focused on instructional technology tools used in the classroom (i.e. graphing calculators). Technology strategies integrated into the mathematics classroom produced a small statistically significant weighted average effect size of +0.16 when the intervention of technology was used in the classroom. More specifically interventions such as technology-based curriculum had an effect size of +0.15 and technology tools +0.17 compared to when those interventions were not used. From Rakes et al. meta analysis, the in-classroom strategies (i.e. technology curriculum, and use of technology tools) supply concrete methods for improving student achievement without utilizing traditional drill and practice techniques.

Li and Ma (2010) conducted a meta-analysis of 46 primary studies, involving a total of 36,793 students to assess the effects of computer technology on mathematics achievement. The investigation focused on 85 effect sizes which were based on retrieved empirical research students that focused on the use of technology and the effects on mathematics achievement. The average weighted Cohen's d was 0.28 SD with a 95 percent confidence interval from 0.13 to 0.43. At the alpha level of 0.05 both averages had a statistically significant positive effect of technology on mathematics achievement. The analysis paid particular attention to studies that focused on (a) gender, (b) race, (c) socio-economic, (d) special education, (e) type of education (i.e. elementary or secondary), and (f) class as the unity of analysis. Findings revealed that gender, race and socio-economic groups benefitted equally in terms of the effect of computer technology in the classroom and mathematics achievement. Furthermore, the method of teaching had the largest effects of technology on mathematics achievement (1.00 SD). When teachers practiced constructivist approaches to teaching, technology had a stronger effect on mathematics achievement compared to when teachers used it for traditional drill and practice methods.

Technology has become a creative, interactive, flexible learning resource for teachers to provide in the classroom. Research has suggested that technology has the potential to improve student outcomes in mathematics. However, despite the positive effects of technology integration, today's national technology standards lack guidelines on how to produce computer literate teachers and how to properly incorporate instructional software into everyday classroom teaching. Reports have demonstrated that teachers who are unprepared to integrate technology into classrooms will integrate it ineffectively. The next section demonstrates the importance of teacher technology competency on student outcomes.

Education Model: Technology, Pedagogy, and Content Knowledge (TPACK).

Teachers are the backbone of the educational system and can either promote or hinder students' success in the classroom. Understanding how to interweave the different kinds of complex knowledge structures and skills into dynamic and multi-layered contexts within the classroom is a complicated task for teachers (Spiro and Jehng 1990; Mishra et al. 1996). In order to be effective in the classroom, teachers must regularly evaluate and modify their approaches, creating an environment that is well-organized to support different domains of learning (Glaser 1984; Shulman 1986; Putnam and Borko 2000). These domains of learning integrate a teacher's knowledge of subject matter, understanding of how a student thinks and learns and how to promote technology for effective learning.

The development of technology has dramatically changed the process of education in the classroom. However, it has become clear that simply introducing technology into the educational process through institutionalization and organizational contexts is not enough; what is critical is how teachers incorporate technology into their teaching (National Research Council 1999; International Society for Technology in Education 2013; National Research Council 2013; Zhao and Conway 2014). It has become clear that the principle focus of research should be how technology is used and the ways it affects student outcomes (Mishra and Koehler 2009). However, there is a lack of theoretical grounding to understand how the integration of technology into the classroom can improve student outcomes (American Association for the Advacement of Science 1999; Issroff and Scanlon 2002; American Association for the Advacement of Science 2014). The development of an integrated conceptual framework provides researchers with identified themes across multiple constructs. Selfe (1990) finds:

> [A] theoretical perspective . . . not only constrains our current educational uses of computers, but also seriously limits our vision of what might be accomplished with computer technology in a broader social, cultural, or educational context. Until we examine the impact of computer technology . . . from a theoretical perspective, we will continue, myopically and unsystematically, to define the isolated pieces of the puzzle in our separate classrooms and discrete research studies. Until we share some theoretical vision of this topic, we will never glimpse the larger picture that could give our everyday classroom efforts direction and meaning. (p. 119)

It is difficult to establish an educational technology theoretical framework due to the complexity of practitioners' backgrounds, the evolving pedagogical goals and the changing context of the classroom (Ferdig et al. 2004). In the following section, I address a theoretical model that provides a conceptual framework to effectively assessing technology integration into the classroom. This section will cover the following:

- technology integration into the classroom;
- brief history of technological pedagogical content knowledge (TPACK);
- content knowledge (CK);
- pedagogy knowledge (PK);
- pedagogy content knowledge (PCK);
- technological knowledge (TK) and technological content knowledge (TCK);
- technological pedagogical knowledge (TPK);
- technological pedagogical content knowledge (TPACK); and
- implications of the TPACK theoretical framework.

This section provides a conceptual model that focuses on the relationship between technology and teaching, and the ways it can transform student outcomes.

Technology Integration in the Classroom: There are clear barriers to effectively utilizing technology in the classroom to enhance student outcomes. In order to decrease those barriers, theoretical approaches have been established to understand the interaction that occurs between teachers' knowledge of technology and their actual application and use of it in the classroom. Technology integration does not fit a one-model approach, since teachers and classroom contexts vary substantially. Thus, technology "should be creatively designed or structured for particular subject matter ideas in specific classroom contexts" (AACTE Committee on Innovation and Technology 2008: 39). Approaches to successful technology integration in the classroom require teachers to understand the complexity of technology and adapt their usage to accommodate the type of students they are teaching.

Research has found that student success is strongly correlated with the effectiveness of a teacher's ability to provide the classroom with three core theoretical components: Technology, Pedagogical and Content Knowledge (TPACK). The TPACK framework provides a way to examine the elaborate, multifaceted and situated nature of teacher knowledge and how it affects student outcomes in various subjects. These three components do not work in isolation from one another, but by intersecting and overlapping across the three primary forms which create four additional components: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPACK). The model below illustrates these seven intersecting components of the TPACK framework.

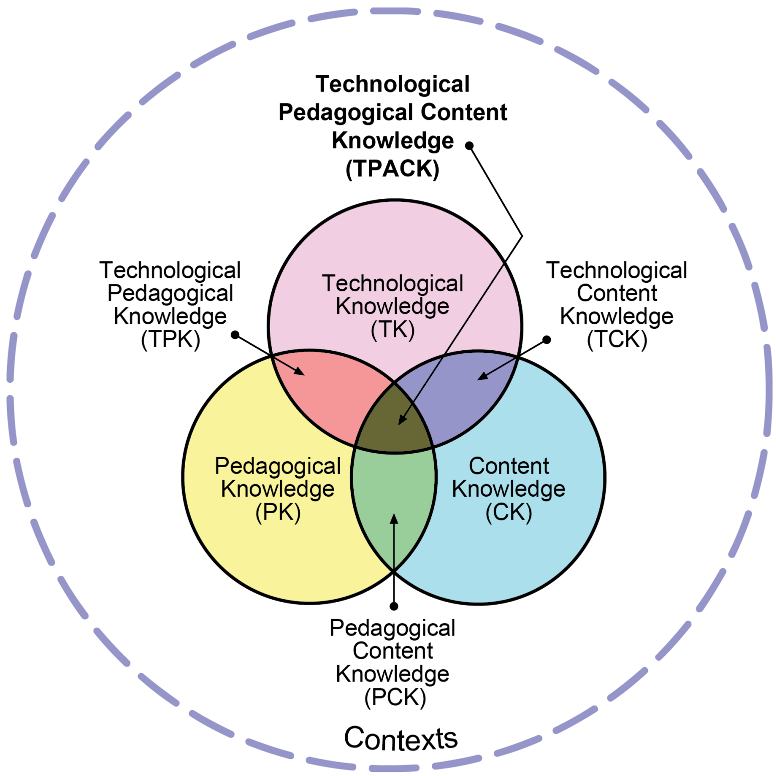

Figure 3: Technological Pedagogical Content Knowledge (TPACK)
Source: Reproduced by permission of the publisher, © 2012 by tpack.org

Understanding the theoretical dynamics between these components of knowledge and where they are situated in the unique contexts of the learning environment of the classroom assists teachers to effectively integrate technology into their pedagogy. However, every learning environment has a unique context that must be taken into consideration, incorporating factors such as school-specific factors, individual teachers, grade-levels, demographics, culture and other variables that affect the student learning environment. The next section provides a brief history of TPACK, starting with Shulman's idea of pedagogical content knowledge (PCK) and Mishra and Koehler's

(Mishra and Koehler 2008) extension of TPACK.

Brief History of TPACK: In the 1980s, Shulman's research introduced the theoretical framework of Pedagogical Content Knowledge (PCK), claiming that teachers' pedagogy and subject-content knowledge were two important areas that intersect and overlap during classroom instruction (Shulman 1987: 6). His model was a new perspective focusing on the intersections of pedagogical techniques and the representation and formulation of concepts during classroom instruction. Shulman investigated individual teachers' content knowledge and how they applied that information to teaching difficult concepts to students, particularly in math and science. He explored teachers' strategies for addressing students with learning difficulties, providing them with meaningful and appropriate conceptual representations of materials during classroom instruction. In order for teachers to be successful, they had to tackle the problems of both content and pedagogy at the same time by determining "the aspects of content most germane to its teachability" (Shulman 1987: 9). The PCK framework also examines the individual student in order to understand the particular strategies that the student utilizes in order to learn the content material given by the teachers. Shulman investigated how students participate in the classroom environment and the types of tools utilized at home for learning and studying the materials.

In the 1980s, technologies were not in the foreground of the literature on teaching, learning and education. Thus, Shulman did not incorporate technology into the theoretical framework that he established between pedagogy and content knowledge. However now that new technologies have come to the forefront of educational discourse, the nature of the learning environment has changed dramatically. Mishra and Koehler (2005; Mishra and Koehler 2006; Mishra and Koehler 2007) have expanded Shulman's model to understand the relationship that exists between content (the actual subject matter), pedagogy (methods of teaching and learning) and technology (chalk boards and laptops). Expanding on Shulman's original work, Mishra and Koehler illustrated the connection, interaction, affordances and constraints between content, pedagogy and technology, terming their model TPCK. In 2009, Cox and Graham (2009) added to this model by incorporating in pedagogical and content knowledge as it applied to technology and developed the TPACK framework.

Content Knowledge (CK) theory discusses the importance of the teacher's ability to understand, interpret and discuss the *subject matter* appropriate for the grade level they are teaching. An effective teacher successfully articulates the content and materials that are suited for the audience they are presenting the information to. For example, teachers need to understand that the content to be covered in elementary school math is different than what is covered in middle and high school. Thus, their approaches should be situated based on the needs of the students. Shulman (1986) found that teachers' "content knowledge would include knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches toward developing such knowledge" (Mishra and Koehler 2009: 67). He found that math teachers must provide four things: knowledge (facts, concepts and relationships); methods (knowledge creation and validation processes); purposes (reasons why the discipline exists); and forms of representation (genres and symbol systems)

(Shulman 1986: 18). Shulman found that a teacher's educational background, pre-service preparation and in-service professional development profoundly affect their understanding of the math discipline and the basic processes to develop students' fundamentals. In the case of math, this includes knowledge of facts such as multiplication, division, fractions and integers. Teachers who do not have a comprehensive understanding of math content knowledge can damage the student's understanding of math by providing incorrect information and develop misconceptions about math fundamentals (Pfundt and Duit 2000; National Research Council 2013).

Pedagogical Knowledge (PK) is a teacher's understanding about the different methods, processes and practices that are utilized during classroom instruction and student learning. PK incorporates the level of knowledge the teacher has on techniques or methods to utilize during classroom instruction, with particular focus on the purpose, values and aims of the overall educational experience of the students. Furthermore, PK includes knowledge of lesson planning, strategies for assessing and evaluating students' learning ability, how the student learns and understands the materials, and how to employ different classroom management skills based on the environment and needs of the students. Teachers with a deep understanding of pedagogical knowledge recognize the importance of how students construct and acquire knowledge and skills and how they view learning and education. Furthermore, teachers who have a solid understanding of pedagogical knowledge comprehend developmental, social and cognitive theories of learning, and how to utilize those theories in the classroom environment to support positive student outcomes.

Pedagogical Content Knowledge (PCK): As Shulman suggested, the concept of Pedagogical Content Knowledge (PCK) blends together the two ideas of teachers' pedagogical knowledge and content knowledge into one combined conceptualization which transforms the theory of teaching and learning. According to Shulman, teachers who have the ability to fully comprehend the subject matter are in turn able to effectively determine how to best present the materials to their particular audience. Teachers with a strong understanding of PCK are able to determine the best approaches to learning based on the students' prior knowledge of the subject, specifically potential misconceptions, misapplications, strategies to learning and learning differences. Teachers therefore adapt their approaches to meet the conditions of their environment and promote effective learning strategies.

Hashweh (2005) outlines the objective of PCK and provides the following definition:

> Pedagogical content knowledge is the set or repertoire of private and personal content-specific general event-based as well as story-based pedagogical constructions that the experienced teacher has developed as a result of repeated planning and teaching of, and reflection on the teaching of, the most regularly taught topics. (p. 277)

Extending on this definition, PCK is also "concerned with the representation and formulation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior knowledge and theories of epistemology" (Mishra and Koehler 2006: 1027).

Depaepe et al. (2013) and Voogt et al. (2013) found that teachers acquire PCK in three different ways: (1) teachers' awareness of the way students learn, (2) teachers' own subject matter knowledge (3) teachers' ability to synthesize subject matter. Lannin et al. (2013) found that PCK in teachers who specifically teach math are continuously changing as they acquire more knowledge about the subject-content, learn about pedagogy (what works and what doesn't work), and are learning better methods that suit the particular population of students they are teaching. McCaughtry's (2005: 385) research found PCK is a way of "connecting the student to the curriculum through teachers' knowledge of the student and teachers' knowledge of teaching the content." Yet, McCaughtry also criticized the framework for not incorporating the emotional, social and cultural influences that affect the students' ability to learn.

Technological Knowledge (TK) is in a state of continuous change, as traditional forms of technology such as whiteboards and paper books are replaced by more advanced technologies such as computers, the internet and software packages. With these rapid changes, new skills are required in order to successfully navigate and utilize the new digital technologies. Individuals need to acquire specific skill sets in order to operate computer hardware and software tools. For example, hardware-technology knowledge includes the ability to install and remove devices, programs and documents and software knowledge is the ability of the user to understand the functions of the programs being utilized. Since digital technology (hardware and software) is rapidly changing, knowledge acquired quickly becomes obsolete, and knowledge of the technology applications is critical, if educators are to develop the most appropriate tools for successful learning outcomes.

Technological Content Knowledge (TCK) applies to how technology and content are mutually related with each other, both constraining and influencing one another. As newer digital technologies emerge, they can afford a wide range of instructional materials, providing teachers with adaptable tools to adjust and meet the unique learning needs of their students. Teachers need to comprehend their subject matter and understand how the subject can be altered by using hardware and software in their classroom. Since technology can affect learning, it is important for teachers to acquire the knowledge to understand the impact of technology on the learning practices of a given discipline. The teacher's role is critical to developing and choosing the most suitable technological tools to support the content and the needs of the students. Teachers have to understand technology and be able to make an educated decision on the amount of time to spend on technology during the day and the programs that are most suitable for their students' needs to promote effective learning. By effectively integrating technology into the curriculum, teachers can advance student learning by offering them additional representations of classroom materials and providing a large degree of flexibility with learning styles.

For example, with the advent of new online learning programs, digital computing technologies have changed the nature of math curricula. Teachers can utilize digital technology to place a greater emphasis on mathematical representations, simulations, graphical manipulations and visual presentations. Technology can alter learning by making available new types of representations to illustrate content ideas and transform learning. Accordingly, theory on TCK finds that technology and content knowledge can simultaneously restrain and influence each other, and teachers need to fully understand the subject matter they are teaching and how to apply technology effectively in order to represent and construct materials to assist their students in the learning process (Niess et al. 2009).

Technological Pedagogical Knowledge (TPK) provides a theoretical framework of how a teacher's understanding of methods, practices, designs strategies and techniques can be bolstered by technological tools. In order for teachers to foster TPK in their classroom environment, they must understand the disciplinary contexts within which they function. Teachers must look beyond the common uses of technology such as didactic approaches to learning (i.e. drill and practice software programs) and employ constructivist approaches, reconfiguring them for customized pedagogical purposes. Thus, teachers must have an "understanding that a range of tools exists for a particular task, the ability to choose a tool based on its fitness, strategies for using the tool's affordances and knowledge of pedagogical strategies and the ability to apply those strategies for use of technologies." (Mishra and Koehler 2007: 2219)) In order for teachers to effectively use the TPK model, it requires them to think outside the box in a creative and open-minded approach to advancing student outcomes.

Technological Pedagogical Content Knowledge (TPCK): provides a framework that illustrates how all three "core components" interact simultaneously. (Mishra and Koehler 2006) summarized the TPCK theory as providing a:

> "basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of

> students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones" (Mishra and Koehler 2006: 1029).

The model utilized in this study illustrates how technology integration into teaching and learning communities operates in conjunction with content and pedagogical knowledge and cannot be effectively used in isolation. Every teaching situation presents a unique environment in which the teachers need to be skillful to combine these three core factors to provide flexible solutions to navigate their teaching space within their specific contexts. If teachers view these core areas in isolation, they ignore the complex roles and relationships that exist, oversimplifying the solutions to increase student outcomes which can potentially lead to failure. Teachers, "need to develop fluency and cognitive flexibility not just in each of the key domains (T, P and C), but also in the manner in which these domains and contextual parameters interrelate, so that they can construct effective solutions. This is the kind of deep, flexible, pragmatic and nuanced understanding of teaching with technology we involved in considering TPACK as a professional knowledge construct" (Mishra and Koehler 2009: 67). With the increase in online learning platforms, educators have to rethink their core pedagogical issues and how to best connect students with the content by integrating software and online programs into their curricula.

Implications of the TPACK Framework: Effectively integrating and utilizing technology in the classroom is a difficult task for most educators. The TPACK theoretical framework illustrates that teaching and learning have separate and combined responsibilities. In order to successfully incorporate technology into curriculum, teachers must understand, maintain, create and re-establish a dynamic equilibrium with the three core components: technology, pedagogy and content knowledge. The primary goal of using TPACK is to understand the relationship between the teachers' actions and their observable effects and the teachers' content knowledge and thought processes (Koehler and Mishra 2005). This study uses part of the TPACK framework -- TCK, TPK, and TPCK to extend the research by analyzing the observable effects of how teachers integrate technology into their content and pedagogical knowledge during classroom instruction.

Teachers Technology Competency and Student Outcomes.

Educational technology specialists with the Northwest Ohio Educational Technology Foundation stated that "technology is the key to improving student achievement, but without high-quality professional development, technology will never be successful in fulfilling that role" (Dick 2005: 31). In 2012 the President's Information Technology Advisory Committee argued that changes in pre-service teaching programs and in-service professional development programs should be required to properly train teachers on the effective use of technology integration into their classrooms. Supporting this claim, research has suggested that effective technology integration requires at least 80 hours of training, with one-to-one interaction with the teachers to demonstrate ways to integrate technology into the curriculum (U.S. Department of Education 2010). It is important that "teachers receive in-depth, sustained assistance not only in the use of the technology but also in their efforts to integrate technology into the curriculum" (Shapley et al. 2010).

Despite the need for teacher training and competency in computer technology, budgets have remained low to increase these programs for pre-service and in-service programs (Bain 2004; Cavanaugh et al. 2007; Shapley et al. 2010). Research continues to illustrate that few teachers receive any professional development courses on technology, and those who do receive it have insufficient duration and/or quality to stimulate pedagogical changes (Zucker and Hug 2007; Darling-Hammond et al. 2009). Kruse (Kruse 2013) find that the traditional methods of technology training for teachers only focuses on "basic skills" and does not provide a "deep understanding" for teachers to adequately unlock the power and potential of technology for pedagogy purposes.

The lack of teacher preparation and professional development programs is one of many reasons why teachers ineffectively integrate technology into the curriculum (Shapley et al. 2010). Literature in the field has started to examine the connection between computer access, usage and professional development that most benefits teachers and students.

For example, Silvernail and Lane (2004) and Silvernail and Buffington (2009) conducted an analysis of the one-to-one laptop initiative in Maine. In 2001, the Maine Learning Technology Initiative (MLTI) was initiated in order to counter the influence of inequalities between high poverty and low poverty school districts. The Maine technology project distributed resources among their entire state population by embarking on an ambitious program to provide a laptop to all 7th and 8th grade students and teachers (Silvernail and Lane 2004). By 2004, "34,000 students and 3,000 teachers" had received a laptop computer with access to the Internet and software programs. Shortly after research findings revealed that teachers with higher computer competency and computer literacy levels “who have participated in more professional development workshops and activities” had “developed instructional materials, conducting research related to their instruction and communicating with colleagues” better compared with those teachers with little or no background in technology integration (pg. 9-11). Their results reported that “the more experience the teachers have with the laptops, the greater the impact on their curriculum and instruction” (pg. 16).

Elaborating on Silvernail and Lane’s (2004) examination of Maine’s one-to-one laptop programs, Warschauer (2010) found that students from high poverty areas had less computer experience, less likelihood of a family member with experience to guide them, and thus had more difficulty using the laptops. Teachers in high poverty schools were more likely to be ill-prepared to effectively integrate technology into the classroom, had less experience and/or professional technology classes, and were less likely to have a technical support system (i.e. technical staff) in the school. The report did find that there were several high poverty schools that did effectively integrate technology; however, those schools invested in “well-trained and highly committed teachers...that could carry out exemplary technology-enhanced instruction with culturally and linguistically diverse low-SES students” (pg. 200). These teachers used higher order approaches to technology to enable the students to improve their critical thinking skills, which supported an in-depth learning environment.

Further evidence suggests that teachers specifically in disadvantaged school districts tend to use technology instruction for lower-order tasks (Shapley et al. 2010). Teachers reported that one of the major obstacles for effectively integrating technology was the lack of sufficient time to learn the technology and develop lesson plans to incorporate it into their curriculum (Sorma 2008). Sclater et al. reported that Maine's one-to-one laptops were unsuccessful at promoting student achievement because teachers reported that technology: "a) requires extra time to plan learning activities; b) is too costly in terms of resources, time and effort; and c) requires software-skills training that is too time consuming" (Sclater et al. 2006: 24). Thus, Sclater et al. believed that giving teachers more professional development to understand effective ways to implement technology into math and reading instruction would influence teachers to effectively incorporate technology into their program and improve student achievement. Similarly, Baker, et al. (1994) as well as Larry Cuban (Cuban 1986; Cuban 2009) state that teachers were unable to effectively use technology themselves and were not prepared to effectively integrate and utilize the program in their instructional techniques. Thus, teachers utilized computers as an aid to reinforce basic skill levels through drill and practice techniques.

Addressing these complicated concerns requires researchers to rethink their theoretical approaches to teacher education and professional development, specifically the methods to analyze the teachers' approaches to effectively integrating technology in the classroom. As contextual and social factors increase, so does the complexity of the integration of technology into the classroom. Approaches to technology integration in pre-service and in-service programs often offer a one-size-fits-all perspective; however, teachers work in an array of learning environment where these approaches might not be appropriate. For these reasons many teachers are inadequately equipped to effectively promote technology in the classroom.

Summary

This section discussed the framework to understand the academic achievement gaps from a historical context to present day issues, focusing on racial and economic barriers. As the achievement gap persists, the nation has responded by providing financial resources for programs to minimize educational inequalities. Funding has been provided to school districts across the nation to provide access to computer technology, with the hopes it would enhance learning and increase student outcomes at home and within the classroom (International Society for Technology in Education 2013).

Despite increases in access, the current literature in the field provides mixed results on the effectiveness of technology usage and integration. Specifically, the use of technology for math instruction is particularly low, and it is often utilized inappropriately or for uninspired purposes (Ross 1995; Bain 2004; Shapley et al. 2010). Math based technology programs in high-poverty and high-diversity schools are often employed for mundane and/or lower-order drill and practice tasks. Evidence suggests that the reason behind this is a lack of technology-based professional development programs to support effective integration strategies. This chapter also included a summary of the relationship between students' computer use at home and within the classroom, which was found to have mixed results, making it difficult to draw any conclusions about the relationships.

CHAPTER FOUR: METHODOLOGY

The intent of this study is to furnish critical information to practitioners, educational leaders and policy makers to evaluate the impact of technology within the home and at the school, classroom and teacher levels by comparing the performance of fourth and eighth grade students in 2011 on state standardized math assessments by demographics identified by NAEP including race, socio-economic-status (SES) and urban community status.

As mandated by Congress, the National Center for Education Statistics, a division within the U.S. Department of Education administers and scores the NAEP. The exam is administered in each of the fifty states to achieve a representative sample of the country. Sec. 1111(b) (A) of NCLB required that all states improve their academic standards, and increase student achievement (U.S. Department of Education 2001). In order to gauge the academic progress of each state and school district, NAEP has been administered every two years since 2003 to a randomly selected group of fourth, eighth and twelfth-grade students to test their content knowledge in math, reading, science and writing. Through these assessments, NAEP tracks the educational accomplishments of students at the national, state and district level and monitors any changes in outcomes based on subgroup demographics. The data is reported in aggregated form based on subgroup populations and presented in *The Nation's Report Card* to provide educators and policymakers with accurate and useful information to make decisions about future laws and funding for schools.

Statement of the Problem

The objective of this research study is to evaluate the impact of technology on student math achievement in grade 4 and grade 8 student achievement in 2011. The research focuses on the academic performance of students in four Trial Urban Districts Assessment (TUDA), by comparing their scores to large city (LC) populations and the national sample after controlling for the effects of race, gender and socio-economic-status. The four TUDA's were selected based on their racial demographics or the technology focus of the area, and include the following: Chicago and New York City as the demographics have almost a 50-50 split of African-American and Hispanic, Atlanta and the District of Columbia's focus is on African-American's, Miami and Los Angeles focus is on Hispanic's, and Austin and Boston were selected for their communities technology advancement.

The main purpose of the research study is determine if technology access, frequency and usage have an impact on grade 4 and 8 mathematics student achievement across four areas of investigation: home effects, overall-school effects, teacher effects, and student-reported classroom effects. At the home-level studies have repeatedly shown that home-technology usage can impact student achievement depending on the programs that are being utilized (Sirin 2005; Berliner 2009). At the school and classroom-level research has illustrated that access to technology can impact student achievement; however, little research has been conducted on the type of technology usage implemented within the classroom. Of particular interest are the roles that teachers' exposure to professional development in technology and specific uses of computer technology play in the relationship between student computer usage in the classroom and student achievement in mathematics.

Research has shown that there is a strong relationship between the use of technology in instruction and student achievement (Bebell and Kay 2010; Shapley et al. 2010). However, a majority of the research focuses on a specific technology approach or software application within the classroom and does not illustrate that there is a broad relationship between technology usage as it relates to students' use at home or within the classroom. Nor has research explored the relationship between teachers' instructional practices using computer technology and student achievement. Analysing the NAEP dataset provides a resource to understanding these unexplored relationships.

Research Questions

The research questions guiding this study are broken down into three sections: access, usage, and teacher computer competency as it relates to student achievement. In particular, the study focuses on how the relationship between computer technology use and student achievement differs by race, gender and socio-economic-status.

This study addresses the following three research questions:

1A. How is technology distributed (access) in the home?

i. Are there patterns of equitable access in terms of race, gender and socio-economic-status?
ii. Is there a relationship between access and student achievement?

1B. How is technology distributed (access) in the school?

i. Are there patterns of equitable access in terms of race, gender and

socio-economic-status?
ii. Is there a relationship between access and student achievement?

2A. How do <u>students use</u> technology in the <u>home</u> for math study?

i. Is there a relationship between technology used in the home for math study and math achievement?
ii. What combination of home-technology usage variables affects math achievement the most?

2B. How do <u>students use</u> technology in the <u>classroom</u> for math study?

a. Is there a relationship between technology used in the classroom for math study and math achievement?
b. Is there a relationship between didactic math approaches to technology use and math achievement?
c. Is there a relationship between constructivist math approaches to technology use and math achievement?

2C. How do <u>teachers</u> use technology in the <u>classroom</u> for math study?

a. Is there a relationship between technology used in the classroom for math study and math achievement?
b. Is there a relationship between didactic math approaches to technology use and math achievement?
c. Is there a relationship between constructivist math approaches to technology use and math achievement?

3. How does <u>teacher computer competency</u> affect the types of computer technology they use in grade-four math classrooms?

Data Source

Known as *The Nation's Report Card*, NAEP provides a regular assessment of subject-matter achievement, school environments, and classroom experiences for a nationally representative sample of American students. NAEP assessments are used to compare subject-specific academic performance of students by demographic subgroups and to track their achievement over time. Further, NAEP administers questionnaires to school administrators, teachers, and students for supplemental information (National

Center for Education Statistics 2006).

Before the requirements of NCLB, in 1996 and 2000, NAEP administered mathematics assessments and surveys to fewer than 20,000 fourth and eighth graders. Beginning in spring 2003, the sample size for NAEP studies expanded by approximately 10 times, and the study initiated a regular testing schedule, administering mathematics assessments every other year.

Sample: Design, Selection and Size.

For the selected year: 2011, schools and students were randomly selected to participate in NAEP according to demographic characteristics that make the samples collectively representative of all the nation's students in grades 4, 8 and 12 at public and private schools. The NAEP sample selection process incorporates a probability sample design so that each student and school has a known probability of being selected (the probabilities are proportionate to the estimated number of students in the grade assessed) (NAEP, 2012). This data is cross-sectional, so it does not track students over the progression of their academic career and therefore analysis cannot infer a causal relationship.

The sample for this study will use the NAEP data for the year: 2011, focusing on urban school districts listed under Tribal Urban District Assessment (TUDA). As mentioned earlier, TUDA was originally formed in 2002 to examine the feasibility of NAEP to investigate public school student outcomes within participating large urban school districts. In 2002 only four urban school districts participated, and that number increased to 21 in 2011. Every two years, TUDA adds more urban school districts to their analysis, making it a more robust examination of urban school districts.

Sampling Frame: The NAEP sampling frame is constructed of three different school types: all public schools, urban district public schools, and private schools. For purposes of this study only public schools will be selected for urban, Large City, and national analysis. Each of the sampling frames is outlined below, and for a complete list of the targeted population and sample size by urban school district, large city school district and national information see: Appendix V: Sample population: 2011.

National and State Sample (Public Schools): At the public school level, The Common Core of Data (CCD) serves as the sampling frame of public schools in each state or jurisdiction. The CCD is used as it is a complete list of all operating public schools in each school district, including information such as grades served, enrollment, and location of the school. To ensure that the CCD correctly reflects all public schools in the nation, data is compiled each year by the National Center for Educational Statistics (NCES).

In 2011, NAEP conducted a selection process of public schools using CCD data. Public schools were combined into groups known as strata on the basis of various school characteristic such as extent of minority enrollment, state-based achievement scores, physical location of the school, and median income of the area in which the school was located (U.S. Department of Education 2007b).

The sample population for all public schools in year: 2011 on average included approximately 100 grade-eligible public schools in each of the selected jurisdictions and 62 students from each school were randomly selected to participate in the standardized exam (U.S. Department of Education 2007b).

Urban School District Sample: Since 2002, The Trial Urban District Assessment (TUDA) provides a representative sample of students in urban school districts participating in NAEP, and augmentation of the sample of students selected as part of the state samples. Schools that participate in TUDA assessments are representative of all students in the school district that they reside in. For each school that is sampled within the urban school district, students are randomly selected in that school to participate through a two-stage sample design. This sampling measurement provides reliable data and analysis of student groups within these urban school districts. The total number of students participating in NAEP-TUDA varies across school districts and years. For a full detailed list of TUDA eligibility requirements and urban school districts/students participating see Appendix IV: Trial Urban District Assessments (TUDA) Districts.

Instruments.

The National Assessment Governing Board (NAGB) provides a blueprint for policies regarding NAEP exams, providing specifications for the standardized assessment framework to create, develop, and determine the cognitive and non-cognitive assessment items. Thus, the standardized exam instrument consists of two major components for assessment: subject-specific cognitive items, and non-cognitive items (i.e. background questions on schools, administrators, teachers, and students).

Cognitive Items and Instruments: Subject-specific test questions are designed to assess the amount of content knowledge based on subject area that a student should know, and tests what they do know. Each subject-area cognitive assessment is based on the framework and specifications set out by the U.S. Department of Education and the NAGB, and instruments are developed by committees and practitioners that specialize in each subject area. Item selection for the standardized exam is chosen based on an extensive selection process and includes multiple-choice and constructed-response scores dichotomously and polygamously.

Mathematics Cognitive Instruments: the math assessment is composed of previous NAEP assessments and newly developed assessments of blocks of cognitive items. Administering the previous NAEP math assessment questions allows for researchers to track trends in math performance over the last ten years. All items on the standardized mathematics exam are reviewed by members of the Mathematics Standing Committee and other specialists in math education development. Since 2003, the assessments are assembled into 25-minute blocks compromising of a range of questions that cover the following five areas:

- number sense, properties, and operations;
- measurement;
- geometry and spatial sense;
- data analysis, statistics and probability; and
- algebra and functions.

Each year the number of items on the exam changes but typically ranges between a total of 160 and 190 math questions.

Non-Cognitive Instrument: The NAEP collects data from participating schools from the following people: administrators, teachers and students through non-cognitive (contextual) items and variables. This information is required as part of the federal legislation under the No Child Left Behind Act. In 2002, the NAGB was given final authority over the background items and created The Background Information Framework for the National Assessment of Educational Progress (NAEP), which created a clearly defined purpose and scope for the long-term to collect and analyze NAEP background data.

Per the requirements, there are three types of background data collected: *student reporting categories*, *other contextual/policy information*, and *subject-specific information*. *Student reporting categories* consist of NAEP results that are disaggregated by subgroups of populations: gender, ethnicity/race, socioeconomic status (SES), disability status, and English language learner (ELL) status. It is important to note that a new approach was piloted in 2009 to examine socioeconomic status (SES) which involves creating an enhanced student background questionnaire with items that probe resources in the home, parents' education level, and parents' employment status, among other variables, and uses geocoding software to link students' home addresses to aggregate SES data available from the United States Census Bureau. This approach is still being examined. *Contextual/policy information* assesses data on basic characteristics of the school and student body including variables such as teacher background, qualifications, and experiences. *Subject-specific information* is limited in focus and design but provides a basic set of key problems within each of the subject areas to address in an in-depth manner the level of competency that the student has in the specific subject (U.S. Department of Education 2007b).

Student Questionnaires: The non-cognitive background questions are placed within this questionnaire where appropriate. These background questions ask the students to provide self-reported information about race, school attendance, computer usage (i.e. frequency, access, and usage type), academic performance, educational setting and experience, academic expectations, home setting and experience, student's effort on the assessment, and the difficulty and importance to them of the assessment.

Teacher Questionnaires: The non-cognitive questions devoted to teachers are organized into two different parts. The first part asks respondents to self-report information about their background, training and professional development, years of teaching experience, certifications, degrees, major and minor field of study, course work in education, course work in specific subject areas, the amount of in-service training, the extent of control over instructional issues, and the availability of resources for the classroom (U.S. Department of Education 2007b). The second part of the questionnaire asks respondents to describe classroom instructional information and teacher exposure to issues related to the subject and the teaching of the subject. Within the second part, questions pertain to pre- and in-service training, the ability level of the students in the class, the length of homework assignments, use of particular resources (i.e. computers), and how students are assigned to particular classes (U.S. Department of Education 2007b). Teacher questionnaires on background questions only changed slightly from year-to-year starting in 2005; however, teacher-related computer questions (i.e. frequency, usage type) started in 2009.

Teacher questionnaires are voluntary, but they are encouraged to complete the survey as it provides supplemental information about their experiences, making the NAEP assessment more accurate and complete. These questionnaires are sent to the teachers whose students participated in the NAEP exam.

Weighting Procedures.

Because each school that participated in the assessment, and each student assessed, represents only a portion of the larger population of interest, the results are weighted to make appropriate inferences between the student samples and the respective populations from which they are drawn. Sampling weights are used to adjust for disproportionate representations of groups within the selected sample. For example, lower sampling measurements were used for students who went to schools that enrolled a smaller number of students, or oversampling was conducting in schools with higher concentrations of specific racial groups.

Per NAEP (2014), the final weights assigned to each student as a result of the estimation procedures are the product of the following steps:

- assignment of a "base" weight, the reciprocal of the overall initial probability of selection;
- adjustment of the school base weights to reduce extreme variability, arising from special circumstance;
- adjustments for school and student nonresponse;
- adjustment (if needed) to reflect assignment to a specified assessment subject; and

- adjustment of the student weights to reduce variability by benchmarking to known student counts obtained from independent sources such as the Census Bureau (this procedure only applies to some NAEP assessments).

Data Collection.

Every year the NAEP study design team creates a specific schedule of data collection events to include the following areas:

- assessments of students' knowledge of academic subjects;
- student demographic and background information;
- teacher and school characteristics; and
- information relative to the inclusion of students with disabilities, and English Language Learners (NAEP 2012).

Data Collection: As indicated, based on NCLB requirements, it is mandatory for any jurisdiction or local education agency receiving federal Title I funds to participate in the biennial state assessment of math for grades 4 and 8.

NAEP data collection procedures requests that there is a combined effort of all participating schools, school districts, states and NAEP staff. NAEP field staff coordinate and administer the national and state activities (i.e. sampling) and assessments to eliminate the burden of school staff. Schools provide several staff members to coordinate with NAEP staff to select students and a space for the assessments. NAEP staff typically perform the majority of the assessment process at the participating schools and school districts creating samples of schools and students, gathering background information, collecting data, and ensuring data was secured.

Parents of students who are participating in the assessment are informed before the assessment begins, and are given the opportunity to not have their child participate in the exam. Assessments are fielded every two years for a six-week period starting in the last week of January through the first week of March. The data collection used for this study included January - March for year: 2011.

Variable Construction

The data for this study comes from the NAEP: 2011, and are collected by the National Center for Education Statistics. The data was collected from students, school administrators and teachers in January of 2011, and includes: school characteristics; teacher background, professional development, computer competency, and computer usage; as well as demographic information about students, student achievement, and student-self reported experiences at the home and in the classroom. The analysis uses a nationally representative sample of schools using stratified probability proportional to size.

Student Variables.

Dependent Variables: The dependent variable for this model is the NAEP math assessment scores for fourth and eight grade students. Data was obtained for the year: 2011 which means that students who took the exam did not take the exam the previous or following years. The math assessments include multiple choice and constructed-response questions to measure student achievement (U.S. Department of Education 2014).

Average mathematics scale score results are based on the NAEP mathematics scale, which ranges from 0 to 500 for grades 4 and 8. Results of the NAEP mathematics assessment are reported as a composite scale that combines the results of separately-estimated scales for each of the mathematics content areas: number properties and operations, measurement, geometry, data analysis, statistics, and probability, and algebra. Average scale scores are computed for sub-groups of students, and at the individual student score level.

Achievement-level results are presented in terms of mathematics levels as adopted by the National Assessment Governing Board, and are intended to measure how well students' actual achievement matches the achievement desired of them. For purposes of this study, the dependent variables of student mathematic achievement will use the aggregated student scale score of 0 to 500 on the math portion of the assessment.

Demographic Variables: The following student demographic variables are included in this analysis and were taken from the student self-reports on the student questionnaire for 2011. Demographic variables includes the gender of the student (GENDER), the student's race (SDRACE) and the student's socio-economic status (C051601). Gender (GENDER) was recoded so that male students were represented by 0 and female students were represented by 1. The student's race (SDRACE) was recoded into four dummy-coded groups (African-American, Hispanic, American Indian, and Alaskan/Native Hawaiian), with White/Asian as the referent group. White and Asian students were combined because these students typically have overall higher math achievement scores. There are many debates in the field to determine the meaning of "socio-economic-status" in order to determine one's "social class" (e.g. Duberman, 1976;

Weis, 1988). For purposes of this study, the socio-economic-status of the student (C051601) was recoded so that those who are on the free-lunch program were represented by 0, those that were on the reduced lunch program were represented by 1 and those that did not receive the free or reduced lunch program were represented by 3.

Computer Technology Access Variables.

Variables for this section used the student and school questionnaire for year: 2011. Both the home and school technology access variables are used as independent variables in the analysis, and the dependent variable is the NAEP math composite assessment scores for fourth and eight grade students'.

Home computer technology access variables are collected from the student questionnaire and only measure if the student has a computer at home. School computer technology access variables are collected from the school questionnaire and include: (1) access to technology grade four math, and (2) access to technology grade eight math. Questions examined the percent of classrooms with: a computer or desktop computer, a printer, the Internet, handheld devices available to teachers (e.g., PDAs), and computer technical support. Table 2 below illustrates the home computer usage variables in this model.

Table 2: Computer Technology Access Variables

NAEP Variable	**Model**	**Label**	**Response Code**	**Grade**

B017101	Home: Access	Computer at Home	Yes (0), No (1)	grade four, Grade Eight
C071507	School: Access	Pct classrooms w/ computer: gr 4 math	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	grade four
T088901	School: Access	Pct with technical computer support	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	grade four
C071508	School: Access	Pct classrooms with Internet: gr 4 math	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	grade four
C071509	School: Access	Pct classrooms w/ computer printer: gr 4 math	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	grade four
C071511	School: Access	Handheld devices (e.g., PDAs)	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	grade four
C073007	School: Access	Percent class-rooms w/desktop computer: gr 8 math	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	Grade Eight
C073008	School: Access	Percent class-rooms with Inter-net: gr 8 math	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	Grade Eight
C073009	School: Access	Percent class-rooms w/comput-er printer: gr 8 math	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	Grade Eight
C073011	School: Access	Percent handheld devices avail to gr 8 math tchrs	0% (1), 1-25% (2), 26-50% (3), 51-75% (4), 76-99% (5), 100% (6)	Grade Eight

Computer Technology Usage Variables.

This part of the study represents how computer technology usage (I.V.) can influence student acheivement on the NAEP math exam (D.V.). Three areas of focus will be examined in the usage model: students' self-reported home usage, students' self-reported classroom usage, and teachers' self-reported classroom usage.

To assess *students'* self-reported home and classroom usage, the student questionnaire for year 2011 will be used. All students that participated in the math NAEP assessment were asked to complete the questionnaire to provide additional information on their computer usage in the home and classroom setting.

Both grade four and grade eight *students'* were asked home computer usage questions. grade four home computer technology usage included the following questions: did they use the internet at home, and did they use computer at home for math homework. Grade Eight home computer technology use included: did they use the internet at home, did they use e-mail/message/blog-to get math help, did they use e-mail/message/blog-to talk with friends about math, and did they use computer at home for math homework. Table 3 below illustrates the home computer usage variables in this model.

Table 3: Computer Technology Usage at Home

NAEP Variable	**Model**	**Label**	**Response Code**	**Grade**
M820401	Student Home: Usage	Use the Internet at home	Yes (0), No (1)	grade four, Grade Eight

M823901	Student Home: Usage	Use computer at home for math homework	Yes (0), No (1)	grade four, Grade Eight
M820603	Student Home: Usage	Use e-mail/ message/blog-get math help	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight
M821301	Student Home: Usage	Use e-mail/ message/blog-talk w/friends about math	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight

Next, I assessed *students'* self-reported computer technology usage in the classroom. Both grade four and grade eight asked questions pertaining to students' computer usage; however, each grade level looked at different tasks related to that grade. Based on the literature in the field, these variables were categorized into either didactic or constructivist approaches to computer technology usage. For grade four math students were asked how they used the computer: to make charts or graphs (constructivist), play math games (constructivist), use the Internet to learn things related to math (constructivist) or use computers for drill and practice purposes (didactic). For grade eight math students were asked how they used the computer: for spreadsheet program for math assignments (constructivist), for new lessons on problem-solving (constructivist), to access the internet to learn things for math class (constructivist), or for drill and practice purposes (didactic). Additionally, both grade four and grade eight students were asked to measure how frequently they use the computer for math, and the amount of time they spent per day for math work in the classroom. Table 4 below illustrates the school computer usage variables in this model.

Table 4: Computer Technology Usage at School

NAEP Variable	**Model**	**Label**	**Response Code**	**Grade**
M814301	Student Classroom: Usage	Use computer at school for math	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	grade four, Grade Eight
M814501	Student Classroom: Usage	Use computer to make charts or graphs for math (Constructivist)	Yes (0), No (1)	grade four
M814601	Student Classroom: Usage	Use computer to practice or drill on math (Didactic)	Yes (0), No (1)	grade four
M814701	Student Classroom: Usage	Use computer to play math games (Didactic)	Yes (0), No (1)	grade four
M814901	Student Classroom: Usage	Use the Internet to learn things about math (Constructivist)	Yes (0), No (1)	grade four

M815901	Student Classroom: Usage	Time per day on computer for math work	None (0), Half an hour or less (1), About 1 hour (2), About 2 hours (3), More than 2 hours (4)	Grade Eight
M816001	Student Classroom: Usage	Use spreadsheet program for math assignments (Constructivist)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight
M816101	Student Classroom: Usage	Use computer program to drill on math facts (Didactic)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight
M816201	Student Classroom: Usage	Use computer program for new lessons on problem-solving (Constructivist)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight

M816301	Student Classroom: Usage	Use Internet to learn things for math class (Constructivist)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight
M816401	Student Classroom: Usage	Use calculator computer program for math class	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight
M816501	Student Classroom: Usage	Using graphing computer program for charts for math class (Constructivist)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight
M816601	Student Classroom: Usage	Use statistical computer program for math class (Constructivist)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight

M816701	Student Classroom: Usage	Use word computer processing program for math class (Constructivist)	Never or hardly ever (0), Once every few weeks (1), About once a week (2), 2-3 times a week (3), Every day or almost every day (4)	Grade Eight

Finally, grade four and grade eight *teachers* computer technology approach variables were assessed based on didactic vs. constructivist approaches. Didactic approaches to computer technology involve drill-and-practice software programs, whereas constructivist approaches use higher-order thinking and project based computer programs. I constructed the math-based didactic vs. constructivist approaches to computer technology based on Wenglinksy's model (Wenglinsky 2005). The didactic approach to computer technology will be measured using the following variables: students use of computers to practice/review math. The constructivist approach to computer technology will be measured using the following variables: students uses of computers to extend math learning, students use of computers to research a math topic, students use of computers to draw geometric shapes, students use of computers to play math games, and students use of computers to extend math learning. An additional constructivist variable is added for only Grade Eight: students use of e-mail to discuss math related issues/problems. There are more constructivist variables included in this analysis, and thus analysis will be run individually on each variable, and by grouping variables together.

Table 5: Computer Technology Usage with Teachers

NAEP Variable	Model	Label	Response Code	Grade
T088301	Teacher Classroom: Usage	Availability of computers for teacher/students	Available to both (0), Available only to teacher (1), Not available (2)	grade four, Grade Eight
T106601	Teacher Classroom: Usage	Students use computer to practice/review math (Didactic)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four
T106602	Teacher Classroom: Usage	Students use computer to extend math learning (Constructivist)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four
T106603	Teacher Classroom: Usage	Students use computer to research a math topic (Constructivist)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four, Grade Eight
T106606	Teacher Classroom: Usage	Students use computer to draw geometric shapes (Constructivist)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four, Grade Eight

T106609	Teacher Classroom: Usage	Students use computer to play math games (Didactic)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four
T106610	Teacher Classroom: Usage	Students use computer to use 4-function calculator	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four
T112601	Teacher Classroom: Usage	Students use computer-practice or review math (Didactic)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four, Grade Eight
T112602	Teacher Classroom: Usage	Students use computer-extend math learning (Constructivist)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	grade four, Grade Eight
T112607	Teacher Classroom: Usage	Students use computer-use graphing program (Constructivist)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	Grade Eight

T112608	Teacher Classroom: Usage	Students use computer-e-mail about math (Constructivist)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	Grade Eight
T112609	Teacher Classroom: Usage	Students use computer-play math games (Didactic)	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	Grade Eight
T112610	Teacher Classroom: Usage	Students use computer-use four-function calculator	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	Grade Eight
T112611	Teacher Classroom: Usage	Students use computer-use scientific calculator	Never or hardly ever (0), Once or twice a month (1), Once or twice a week (2), Every day or almost every day (3)	Grade Eight

Teacher Computer Competency Variables.

This part of the study examines how grade four teachers computer compentecy (I.V.) can influence student achievment on the NAEP math exam (D.V). Variables on teachers computer competency are self-reported on the teacher questionnaire for year: 2011.

Teachers' Technology Training and Competency on Computers Grade 4: The data on teacher training on computer usage was only collected at the grade four mathematics for year: 2011. The independent variables used in this study consist of a series of questions addressed to the teachers on their computer competency: professional development for the use of computers or other technology, training in basic computers, training in integrating computers into instruction, training in software applications, training in use of the internet, and training in use of other technology.

Table 6: Teacher Computer Competency

NAEP Variable	Model	Label	Response Code	Grade
T087708	Teacher Computer Competency	Professional development-use of computers or other technology	Not at all (0), Small extent (1), Moderate extent (2), Large extent (3)	grade four
T097501	Teacher Computer Competency	Training in basic computers	Already proficient (0), Have not (1), Yes (2)	grade four
T097505	Teacher Computer Competency	Training in integrating computers into instruction	Already proficient (0), Have not (1), Yes (2)	grade four
T097502	Teacher Computer Competency	Training in software applications	Already proficient (0), Have not (1), Yes (2)	grade four
T097503	Training in use of the Internet	Training in use of the Internet	Already proficient (0), Have not (1), Yes (2)	grade four

T097504	Training in use of the Internet	Training in use of other technology	Already proficient (0), Have not (1), Yes (2)	grade four

Data Analysis Procedures

In order to analyze the effects of technology on student achievement, the data analysis procedures will follow the expanded research model provided in the introduction. This consists of three areas of investigation: access, usage, and teacher computer competency as it effects on student achievement in grades 4 and 8 mathematics for year 2011.

There are four phases to the data analysis procedures. The first phase of the analysis provides a close examination of the collinearity between the predictor variables, to determine if the variables are correlated. This is a necessary to conduct before running the regression model to determine the degree of multi-collinearity. The second phase of the analysis consists of descriptive statistics, which provide a summary of the basic features of the population represented by the sample. This phase also provides a comparison of mean assessment scores to determine if there are any statistically significant differences between the race, gender, and socio-economic status at NAEP standardized achievement results. The third phase of the data analysis will use multivariate multiple regression analysis to estimate the relationship between the independent factors that affect student achievement. The final phase of the data analysis will use the literature in the field to combine variables (i.e. indexing) in order to determine the best combination of access, usage, and teacher computer competency that has the most affect on student achievement.

Phase 1: Testing Assumptions and Measures of Association.

First, an examination of the bivariate correlations between the independent variables will be run. This analysis will determine the relationships the exists between the independent variables, demonstrating if there are statistically significant correlations. As recommended by Field (2000) and Tabachnick and Fidell (2007) these variables will be examined when the value of $p < .01$ and the correlations were not higher than 0.90. Additionally Field (2000) recommended evaluating the Variance Inflation Factor (VIF) values, which illustrates "whether a predictor has a strong linear relationship with the other predictor(s)" (pg. 175). Thus, in this preliminary analysis, all VIF values must remain below 10 and all tolerances statistics above 0.2; this ensured that the multicollinearity assumptions were met for the data (Tabachnick and Fidell 2007). Additionally, analysis will be run to ensure that there are no-influential cases, as well as normality, lineraity, homoscedasticity, and independence of error assumptions are met.

Second, the overall fit of the model will be assessed by examining the Chi-square to determine if a relationship exists between the non-orderable discrete (i.e. nominal) variables. Thus, this statistical test will reveal if the variables are independent and if there is a relationship between the variables. If an association does exist between the variables, than I will determine how strong the association is and what the pattern is of the relationship. This measurement will be reported using Cramer's V and judged based on the range between 0 and 1 with higher values indicating stronger relationships (i.e. 0 to

0.1 will be considered weak, 0.2 will be considered moderate and 0.3 and higher will be considered strong).

Phase 2: Descriptive Statistics.

The first part of the analysis will use descriptive statistics to provide a summary of the basic features of the sample population for the three major areas of interest: access, usage, and teacher computer competency. Each area of interest will have a summary chart based on the four TUDA school districts (i.e.: Chicago, District of Columbia, Miami, and Boston), large city, and nation-wide averages. The means, standard deviations and frequencies will be reported on each of the independent variables of interest and were calculated based on student demographic variables. Where appropriate, a T-test will be used to compare the means between two groups (i.e. male and female), and a one-way ANOVA using Bonferroni corrections will be used in order to compare the means between three or more groups (i.e. race).

Students descriptive statistics will illustrate a summary of individual factors (i.e. race/ethnicity, gender, and socio-economic level) that are related to NAEP scores. This will provide information regarding the relative meaning of scores based on demographic data. The composite math scaled scores will be utilized in the descriptive statistic. A Cross-tabs will be run for all variables that are categorical to assess any statistical differences. While, a Cohen's d (effect size) will be calculated to examine the standardized differences between two means. Differences between demographics on student outcomes for cross-sectional NAEP data are described based on average scaled scores. The spread of the scaled scores within groups will be reported by standard deviation.

Teachers descriptive statistics will provide a summary of teachers profile for the following areas: computer competency, and type of computer usage. This will provide information regarding the level of preparedness of the teachers and the relative meaning of scores based on demographic data. For example, preliminary data indicates that there is lower computer competency of teachers in low-income and minority school districts (Center for Public Education 2005).

This first stage of analysis will furnish basic insight into how the use of computers in mathematics classrooms varies by demographic variables: race/ethnicity, gender, and socio-economic-status. This analysis will use AM Statistical Software, designed by the American Institutes for Research in order to conduct the special weighting and jackknifing which is needed for the NAEP data set.

Phase 3: Ordinary Least Squares Regression - Factors that Influence Student Achievement.

The purpose of this phase is to test the hypothesized model's (see Figures 4 and 5) which explains the complex relationships between technology integration and the effects it has on students' standardized test scores. In the model, the arrows illustrate the direction of factors that influence the type of technology integration which have been identified within the literature. As seen in this model the factors of: access, usage, and teacher computer competency are considered independent variables as it is assumed that they affect the dependent variable student achievement (Inan and Lowther 2010). Since there are more than one predictor variables in this equation, the best statistical method to use is multivariate multiple regression analysis. The results of the overall model will provide an examination and determine if the predictor variables are statistical significance when $p >= .05$. Furthermore, this analysis will also determine the direction of the relationship between the independent and dependent variables.

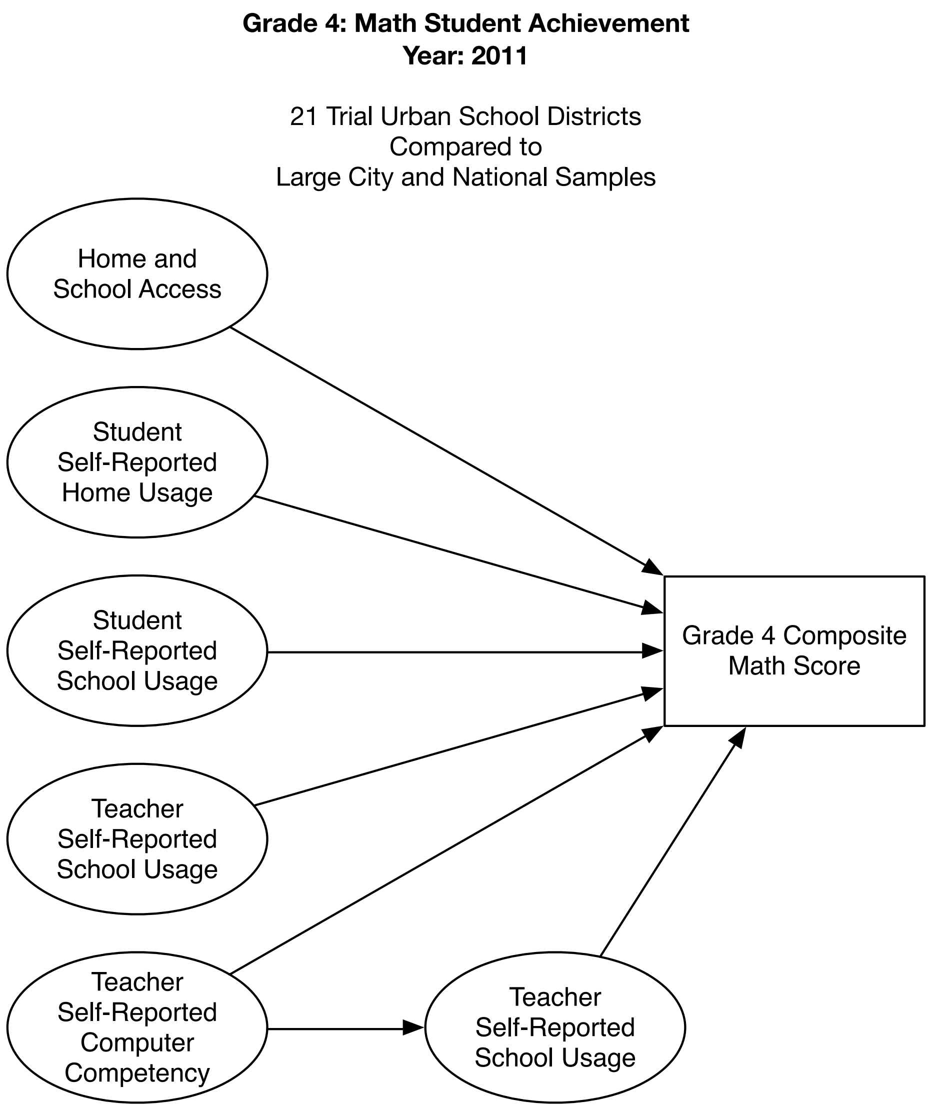

Figure 4: Grade 4 Model of Technology and Student Achievement

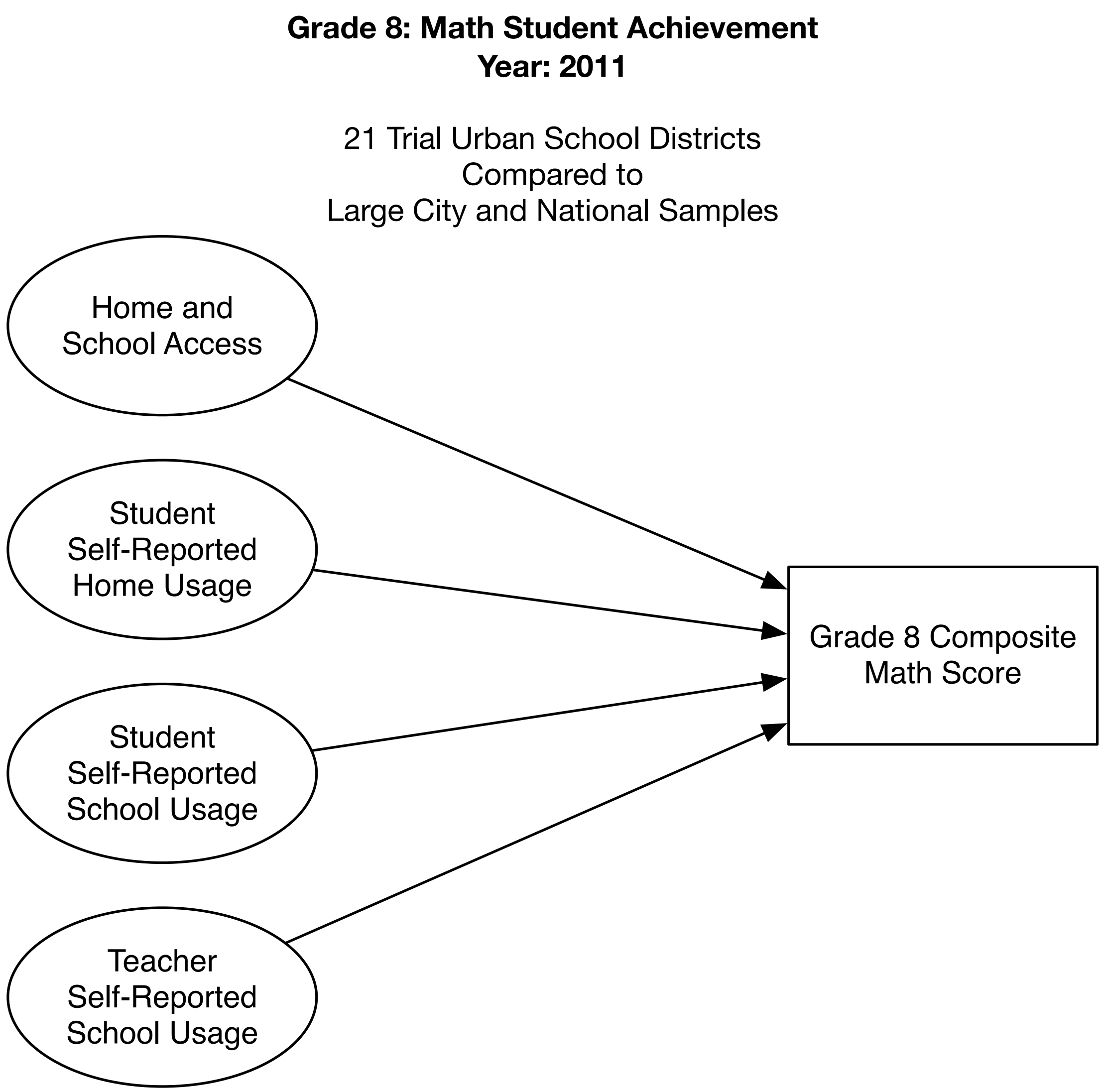

Figure 5: Grade 8 Model of Technology and Student Achievement

The Ordinary Least Squares (OLS) regression statistical model is appropriate for the research design as the independent variables have answer choices that are categorical, and thus are considered non-orderable discrete variables (i.e. nominal), and the dependent variable of student achievement on the NAEP math exam is considered a continuous variable, also known as interval/ratio (Foster et al. 2005). Additionally, there are independent variables in the model that are considered ordinal, and these variables will be re-classified into categorical variables to run this analysis.

Utilizing this method will assist in determining the relationship between the independent variables - access, usage, and teacher computer competency as it affects student academic achievement. OLS regression analysis will determine if an association exist, how strong the association is, and with is the form of the relationship. Furthermore, this analysis will determine the total variation in a dependent variable (student achievement), that can be explained by the level of the independent variables and how much is left unexplained.

Phase 4: Creation of an Index - Factors that Influence Student Achievement.

Since there are a number of independent variables under each of the different levels (home, classroom and competency), indexing will be conducted to determine what combination of independent variables (see tables: 2, 3, 4, 5, and 6) has the most influence on the dependent variable (student achievement). This method of analysis enables the researcher to reduce the large number of independent variables to a small number of latent constructs. The main approach will be a forward selection process, which will involve starting with no independent variables in the model, and then testing the addition of each variable using the Wenglinsky's model. The analysis will determine what combination of independent variables improves the model the most.

In order to perform this technique three methods will be utilized. First, the data will be examined using data exploratory tools (e.g. descriptive multivariate methods) to investigate the patterns in the data. Next, using literature in the field (e.g. Wenglinsky and Mishra) and guided by the research question(s), the data will be examined using the identified natural groupings (i.e. access, usage, and competency). For example, grade four access variables will be indexed separately from student-usage, teacher-usage and computer competency. Next, a factor analysis will be conducted to examine the correlation structure among the natural groupings in the multivariate response set by relating them to a set of common factors (Abeyasekera 2012). Finally, the number of variables will be constructed into indices to create a composite measure of access, usage, and computer competency. The index will be a single value that captures the information for each of the combined values at each of the levels separately. This approach allows the researcher to identify what combination of variables at the access, usage and competency level provides the most impact to student achievement[4].

Instrument Reliability and Validity

Background on the NAEP Instrumentation: In 1969, the federal government and the Education Commission on States joined forces to create the National Assessment of

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4. Since the index did not improve the OLS regression model, the results are located in Appendix VII: Results for Index.

Educational Progress (NAEP). NAEP was created to monitor every few years achievement in 10 learning areas, and to be utilized to examine new policies for educational development (Resnick 1980). In 2002, NCLB accountability provisions under Title I provided new measures to hold states and school districts more responsible for increasing their student achievement standards, setting new content goals and achievement levels (Linn 2003; Institute of Education Sciences 2007). Adequate Yearly Progress (AYP) was a term defined by the federal government for states to measure and report on schools overall student content knowledge, standards and achievement. States set their own standards to meet AYP each year, and report their school's yearly progress on public reports, and directly to parents. The U.S. Department of Education (2004) requires that by 2014, 100 percent of students demonstrate proficiency in all subject matters.

Reliability and Validity of NAEP: Reliability of measurement is defined by as the degree of regularity that the same results will be obtained during studies with similar conditions (Gall et al. 2007). Tuckman (1999: 32) states that "validity of an instrument or study is the extent to which it measures what it is purports to measure." Validity establishes how strong and valid the conclusions are that the researcher postulates. Cook and Campbell state that validity is the "best available approximation of the truth or falsity of a given inference, proposition or conclusion" (Cook and Campbell 1979).

According to Jones and Dindia (2004), as well as a plethora of other researchers, NAEP is the "Gold Standard" to reliably and effectively measure cross-sectional student achievement since 1969. NAEP has gone through substantial reliability testing to ensure that the instruments are useful in predicting outcomes of schools, teachers and students, and examining these predictions based on sub-group analysis (such as ethnicity/race, gender, income, etc).

Starting in 2003, the NAGB provided a framework for content in each of the subject areas. The instrument was developed through a peer reviewed process consisting of a committee of subject area experts, Educational Testing Services (ETS), and NAEP staff who together developed, designed, analyzed and reported on NAEP data.

In 2003, Congress called for an ongoing evaluation of the reliability and validity of NAEP. NCES created a series of external evaluators consisting of panels of subject and technical experts; organizations such as the National Academy of Sciences and universities such as the University of Massachusetts Center for Educational Assessment to evaluate the reliability and validity of the NAEP measurement tool.

The most recent external evaluation team consisted of the University of Nebraska-Lincoln and the University of Massachusetts-Amherst, and in their report, *Evaluation of the National Assessment of Educational Progress,* they concluded that NAEP is one of the most reliable and valid instruments for examining and analyzing student achievement based on sub-groups and subject matter (Buckendahl et al. 2009) Furthermore, after conducting extensive studies the group found evidence basis for test content on standards-referenced assessments which are tied to curriculum standards set by the U.S. Department of Education. In their validity testing, the results are in fact used "to make inferences about students' knowledge and understanding of the National Assessment of Educational Progress and end-of-course (EOC) assessments;" however, "the search for validity evidence is a never-ending process, and future technical reports will include additional information in this regard" (Buckendahl et al. 2009). Therefore, using NAEP data for purposes of this study poses no known major threats to external or internal reliability or validity. This study's results and conclusion are replicable and generalizable to other groups and populations.

Summary

This chapter on the methods for this study provides a description of the data source, data analysis procedures guiding the statistical analysis conducted to answer the research question, and the variable construction for each of the research questions. OLS regression modeling was used as the primary means of analysis to account for the nested nature of the data source. The benefit of using OLS regression analysis is that it provides a statistical method to account for the influence of the grouping agent, and the ability to manage unbalanced data. The data source utilized for this study was NCES-NAEP math standardized exam for year 2011, and for grade 4 and grade 8. NCES-NAEP provides guidelines to ensure proper weighting measurements, which were utilized before any analysis were conducted.

Furthermore, the methodology for this study provides a statistical look into the effectiveness of technology access, frequency, use, and teacher computer competency to promote student outcomes. The evaluation focuses on the impacts of the teacher preparation and computer competency to effectively integrate technology into the classroom, and how/if that effects student achievement. The evaluation focuses on the type of technology driven instructional practices (i.e. didactic vs. constructivist) utilized in classrooms and the type of effects it has on student outcomes. By statistically evaluating the effectiveness of instructional practices, this examination can provide the federal government, policy makers, and administrators with research-based guidelines to effectively integrate technology as a pedagogical approach to math to increase student outcomes.

CHAPTER FIVE: RESULTS

The purpose of this study is to determine if students' access and use of instructional technology is a significant predictor of fourth and eighth grade math achievement test scores. Additionally, this study investigates teachers use and teacher computer competency as it relates to grade four and grade eight student achievement. The quasi-experimental research study analyzed the results of the 2011 fourth and eighth grade composite mathematics score of the NAEP. The analysis focused on the academic performance of students in four TUDA regions. Each region was selected for its specific demographic profile: Chicago's 50/50 split of black and Hispanic, D.C. is predominately black, while Miami is predominately Hispanic and Boston is typically referred to as a 'technology friendly' city. The analysis utilizes these TUDA regions and compares the student scores to large city (LC) populations and the national sample after controlling for the effects of race, gender and socio-economic-status. Of particular interest is the relationship between race, gender, income and parent educational level of students, specific access and usage of computer technology, and teachers' exposure to professional development in technology. Three major research questions guided this study:

1A. How is technology distributed (access) in the home?

   i. Are there patterns of equitable access in terms of race, gender and socio-economic-status?
   ii. Is there a relationship between access and student achievement?

1B. How is technology distributed (access) in the school?

i. Are there patterns of equitable access in terms of race, gender and socio-economic-status?
ii. Is there a relationship between access and student achievement?

2A. How do <u>students use</u> technology in the <u>home</u> for math study?

i. Is there a relationship between technology used in the home for math study and math achievement?
ii. What combination of home-technology usage variables affects math achievement the most?

2B. How do <u>students use</u> technology in the <u>classroom</u> for math study?

a. Is there a relationship between technology used in the classroom for math study and math achievement?
b. Is there a relationship between didactic math approaches to technology use and math achievement?
c. Is there a relationship between constructivist math approaches to technology use and math achievement?

2C. How do <u>teachers</u> use technology in the <u>classroom</u> for math study?

a. Is there a relationship between technology used in the classroom for math study and math achievement?
b. Is there a relationship between didactic math approaches to technology use and math achievement?
c. Is there a relationship between constructivist math approaches to technology use and math achievement?

3. How does <u>teacher computer competency</u> affect the types of computer technology they use in grade-four math classrooms?

This chapter presents the results of the data analysis described in the methodology section. Specifically, the first phase examines: testing assumptions of each of the independent non-dichotomous variables in order to determine the distribution. After testing the assumptions, I describe how the discrete responses are restructured into dichotomous variables by collapsing response choices. Lastly in this initial phase, a brief overview of the weighting procedures, handling of the missing data, and the measures of association will be reviewed. Phase two focuses on the descriptive statistics of the recoded dichotomous variables by providing an analysis of the distributions and bivariate correlations. Phase three presents the findings of the OLS regression analysis, which illustrates Model 1 through 7 for the National data set and only Model 7 for LCs and TUDAs. Phase four was the creation of the index; however, since it did not improve the OLS regression model it was moved to Appendix VII: Results for Index.

Phase 1: Testing Assumptions, Weighting, Missing Analysis and Measures of Association

Prior to running descriptive or multiple regression analysis it is necessary to test the assumptions of the data, to ensure that the data doesn't fail the assumptions. First, I tested the assumptions of each of the independent variables for grade four and grade eight by identifying the mean, the range, standard deviation, skewness, and kurtosis, and by running a histogram. This determined if the data met the requirements for the descriptive and regression analysis. For data that failed to meet the required assumptions, an explanation was provided as to how the data was transformed when it was not considered normally distributed. Next, before running OLS regressions, it was necessary to perform preliminary analysis; otherwise the results can be misleading when other factors are not considered in the equation. Therefore, it was necessary to determine the presence of co-linear factors that are related to one another, producing ambiguous results by using Variance Inflation Factors and a visual representations of different predictor variables through histograms. When predictor variables (or independent variables) are strongly correlated, it can cause coefficient estimates to produce inaccurate information, which can affect the regression model. The consequences of having highly correlated predictors can cause over predicted results, which in turn will mean that the model has less predictive power then assumed.

Testing Assumptions.

Before running the descriptive statistics and multi-regression models, each non-dichotomous predictor variable was analyzed to determine its distribution. A majority of the predictor variables have discrete responses to Likert scale questions and are categorical variables. In order to test the distribution, the mean, standard deviation, skewness and kurtosis were calculated and histograms were examined for each independent variable in grade four and grade eight.

Skewness provides a measure of symmetry, to determine if the data set distribution is symmetric. Normally distributed data has a skewness of zero, while negative values illustrate that the data is skewed to the left (or the left tail is longer compared to the right tail); positive skewed numbers indicate that the data is skewed to the right. Kurtosis is a statistical measurement to determine if the data is peaked or flat relative to a normal distribution. Variables that have a high level of kurtosis tend to have a peak near the mean, and then rapidly decline with heavy tails. While variables with a low kurtosis have a flat top near the mean. Histograms provide a graphical technique to illustrate both the skewness and kurtosis of the NAEP data set variables before and after the variable responses were collapsed.

The following two tables illustrate the variables related to student home access, student school access, student home usage, student classroom usage, teacher classroom usage and teacher computer competency. In order for the variable to be normally distributed, skewness should be near to 0 with a +/-1, and kurtosis should not exceed +/-3 (George and Mallery 2010).

Table 7: National Public Grade Four Descriptive Statistics

	N	Range	Mean	Std Dev	Skewness		Kurtosis	
NAEP Variables	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Std Error**	**Statistic**	**Std Error**
Composite Value	208,993	0 to 500	239.35	27.819	-.281	.005	.045	.011
Home Access								
Computer in home	205,187	1 to 2	1.11	.315	2.460	.005	4.050	.011
School Access								
Pct classrooms w/ computer: gr 4 math	201,953	1 to 6	5.87	.591	-5.537	.005	32.886	.011
Pct classrooms with Internet: gr 4 math	201,779	1 to 6	5.87	.627	-5.756	.005	34.772	.011
Pct classrooms w/ computer printer: gr 4 math	201,507	1 to 6	5.11	1.562	-1.539	.005	.874	.011
Handheld devices (e.g., PDAs)	200,860	1 to 6	2.04	1.627	1.544	.005	1.021	.011
Student Home Usage								
Use the Internet at home	190,031	1 to 2	1.16	.367	1.856	.006	1.444	.011
Use computer at home for math homework	204,185	1 to 2	1.78	.415	-1.347	.005	-.186	.011
Student Classroom Usage								
Use computer at school for math	204,900	1 to 5	2.00	1.329	1.113	.005	-.085	.011
Didactic: Use computer to practice or drill on math	204,694	1 to 2	1.54	.498	-.173	.005	-1.970	.011
Didactic: Use computer to play math games	204,534	1 to 2	1.25	.433	1.156	.005	-.664	.011
Construct: Use computer to make charts or graphs for math	202,886	1 to 2	1.83	.376	-1.755	.005	1.078	.011
Construct: Use the Internet to learn things about math	204,545	1 to 2	1.54	.499	-.149	.005	-1.978	.011
Teacher Classroom Usage								

Availability of computers for teacher/students	195,064	1 to 3	1.10	.323	3.259	.006	10.544	.011
Students use computer to use 4-function calculator	194,839	1 to 4	1.78	.907	.874	.006	-.291	.011
Didactic: Students use computer to practice/review math	194,981	1 to 4	2.46	.995	-.088	.006	-1.071	.011
Didactic: Students use computer to play math games	194,952	1 to 4	2.41	.896	-.047	.006	-.809	.011
Construct: Students use computer to extend math learning	194,895	1 to 4	2.22	.977	.179	.006	-1.075	.011
Construct: Students use computer to research a math topic	194,839	1 to 4	1.35	.689	2.063	.006	3.659	.011
Construct: Students use computer to draw geometric shapes	194,635	1 to 4	1.30	.626	2.253	.006	4.866	.011
Teacher Computer Competency								
Prof dev-use of computers or other technology	200,136	1 to 4	2.19	.932	.341	.005	-.771	.011
Training in basic computers	200,173	1 to 3	1.76	.906	.487	.005	-1.605	.011
Training in software applications	199,807	1 to 3	2.23	.816	-.437	.005	-1.367	.011
Training in use of the Internet	199,155	1 to 3	1.75	.889	.511	.005	-1.541	.011
Training in use of other technology	199,828	1 to 3	2.34	.678	-.532	.005	-.771	.011
Training in integrating computers into instruction	199,997	1 to 3	2.53	.730	-1.215	.005	-.062	.011

Table 8: National Public Grade Eight Descriptive Statistics

NAEP Variables	N	Range	Mean	Std Dev	Skewness		Kurtosis	
					Statistic	Std Error	Statistic	Std Error
Composite Value	175,238	0 to 500	282.04	34.848	-.147	.006	-.116	.012
Home Access								
Computer in home	171,513	1 to 2	1.08	.264	3.212	.006	8.318	.012
School Access								
Availability of computers for teacher/students	159,093	1 to 3	1.17	.396	2.168	.006	3.813	.012
Student Home Usage								
Use the Internet at home	164,251	1 to 2	1.08	.273	3.062	.006	7.374	.012
Use computer at home for math homework	170,754	1 to 2	1.80	.400	-1.504	.006	.261	.012
Use e-mail/message/ blog-get math help	162,048	1 to 5	1.89	1.242	1.231	.006	.284	.012
Use e-mail/message/ blog-talk w/friends about math	163,485	1 to 5	1.84	1.265	1.398	.006	.705	.012
Student Classroom Usage								
Use computer at school for math	170,634	1 to 5	1.55	1.048	2.022	.006	3.171	.012
Time per day on computer for math work	170,493	1 to 5	1.69	.914	1.286	.006	1.164	.012
Use calculator program for math class	167,058	1 to 5	1.78	1.180	1.437	.006	.943	.012
Didactic: Use program to drill on math facts	168,497	1 to 5	1.70	1.121	1.605	.006	1.570	.012
Constructivist: Use spreadsheet program for math assignments	168,779	1 to 5	1.50	1.014	2.139	.006	3.686	.012
Constructivist: Use program for new lessons on problem-solving	168,115	1 to 5	1.85	1.255	1.318	.006	.467	.012
Constructivist: Use Internet to learn things for math class	167,729	1 to 5	1.65	1.067	1.686	.006	1.964	.012
Constructivist: Use graphing program for charts for math class	166,952	1 to 5	1.46	.937	2.185	.006	4.127	.012

Constructivist: Use statistical program for math class	166,557	1 to 5	1.34	.820	2.676	.006	6.843	.012
Constructivist: Use word processing program for math class	166,468	1 to 5	1.43	.924	2.369	.006	5.047	.012
Teacher Classroom Usage								
Students use computer-use four-function calculator	158,493	1 to 4	2.07	1.222	.575	.006	-1.323	.012
Students use computer-use scientific calculator	158,685	1 to 4	2.23	1.264	.341	.006	-1.569	.012
Students use computer-use graphing calculator	158,674	1 to 4	1.82	1.132	1.022	.006	-.531	.012
Didactic: Students use computer-practice or review math	158,768	1 to 4	1.75	.891	.963	.006	-.016	.012
Didactic: Students use computer-play math games	158,641	1 to 4	1.59	.736	1.056	.006	.433	.012
Constructivist: Students use computer-extend math learning	158,562	1 to 4	1.62	.799	1.164	.006	.655	.012
Constructivist: Students use computer-research a math topic	158,822	1 to 4	1.24	.548	2.519	.006	6.722	.012
Constructivist: Students use computer-draw geometric shapes	158,692	1 to 4	1.17	.481	3.172	.006	10.912	.012
Constructivist: Students use computer-use graphing program	158,485	1 to 4	1.34	.659	2.104	.006	4.170	.012
Constructivist: Students use computer-e-mail about math	158,556	1 to 4	1.37	.732	2.038	.006	3.441	.012
Teacher Computer Competency								
Prof dev-use of computers or other technology	159,306	1 to 4	2.43	.950	.122	.006	-.901	.012

Teacher computer competency at both grade four and grade eight appeared to be normally distributed between three answer choices: “no, I am already proficient”, “yes, I have had training” and “no, I have not received training.” However, for both grade four and grade eight, most items under access and usage were outside the acceptable range of skewness and kurtosis. For items related to home and classroom access, it was attributed to the large percentage of students who reported that they did have access. Both students and teachers in grade four and grade eight did not have a normally distributed amount of responses for usage variables, with some variables weighing heavily either toward “never or hardly ever” or “once/twice a month” and “once or twice a week.” In order to create a more normally distributed range of answer responses, both square root transformations and logarithmic analysis were conducted; however, the results did not garner a normally distributed range resulting in unacceptable skewness and kurtosis results.

Since the results continue to be abnormally distributed for access and usage, there were three different ways to continue with the analysis:

> 1). Violating the assumptions of normality and continuing to use the non-normally distributed values in the analysis. This approach could lead to reporting incorrect coefficients and measures of significance for all of the variables.
>
> 2). Creating a filter for all future analysis to only include students who answered “once every few weeks”, “about once a week”, “2 to 3 times a week” and “every day or almost” and eliminating all responses to those that responded “never or hardly ever”. The draw back to utilizing this filtering approach is that it would eliminate students who responded “never or hardly ever” to variables. For example, there were 51.1 percent of grade four and 67 precent of grade eight who responded “never or hardly ever” to variable M814301: Use Computer at school for math. Eliminating this answer choice would exclude over half of all students responding to the survey.

> 3). Collapsing response categories of interest into dichotomous variables. Students who responded “once every few weeks”, “about once a week”, “2 to 3 times a week” and “every day or almost” would be collapsed into one category and coded as a “1”, and those that responded “never or hardly ever” would be coded as “0”. This result captures all respondents answering the survey; however, this method results in losing a degree of precision in the regression analysis.

For purposes of this dissertation, it was decided to use the third approach and collapse response categories into dichotomized variables for access, usage and teacher computer competency at the national level. This statistical application does limit the precision of responses to these variables; however, the approach was justified since the other two approaches would have greater consequences to the overall OLS results. The following tables provide a comparison of the original variables and the new dichotomous variables.

Weighting and Missing Analysis .

Due to the complexity of weighting procedures with the NAEP 2011 database, NCES provides researchers with specific codes to utilize for proper weighting procedures. Each student is assigned the weight to be used for making inferences about students and their targeted population. The weight contains five components: 1). the base weight, 2). school nonresponse adjustments, 3). student nonresponse adjustments, 4). school weight trimming adjustments, and 5). student weight trimming adjustments. Per NAEP 2011,

> “the base weight is the inverse of the overall probability of selecting a student and assigning that student to a particular assessment[...]the base weight is adjusted for two sources of non-participation: school level and student level. These weighting adjustments seek to reduce the potential for bias from such non-participation” (U.S. Department of Education 2014).

School and student nonresponse adjustments are used to reduce the mean square error of survey estimates. School and student weight trimming adjustment procedures involve detecting and reducing extremely large weights that were not anticipated in the design of the sample. In addition to the final full-sample 67 weights, a set of replicate weights using jackknifing, strata and clustering are applied to the analysis. These procedures help to ensure that valid inferences can be drawn from the analysis and assessments are fully representative of the targeted populations.

Measure of Association.

Another important preliminary analysis prior to running OLS regression is to examine the measure of association between predictor variables. Measuring the association can illustrate if there are correlations or multiple correlations of sufficient magnitude between the predictor variables that could adversely affect the regression estimates. Running an analysis of tolerance and the variance inflation factor (VIF) can determine if there is multicollinearity between the predictor values. Tolerance values less than 0.20 and VIF values greater than 4 illustrate that there may be a potential issue with multicollinearity. Among grade four and grade eight variables, tolerance values ranged from 0.39 to 0.97, and VIF values did not exceed 3.0 which are acceptable values. Tolerance and VIF values for both grade four and grade eight are presented in the Appendix VI: Table 35 and Table 36.

Furthermore, another inspection confirming that there were no issues regarding multicollinearity was to examine the correlations and associations between the independent variables to detect a high level of association. Bivariate correlations among the predictor variables did not illustrate high levels of collinarity when examining at the access, usage and competency levels.

Phase 2: Descriptive Statistics

The following section provides descriptive statistics to describe the basic features of the data at the national, Large City (LC) and TUDA levels. The descriptive statistics provide an initial analysis of the frequency, central tendency (means), and standard deviations. Furthermore, an independent t-test was calculated for each of the independent variable outputs to determine if there was a significant difference between the mean math scores of those students who had the technology intervention vs. those that did not. Significance will be illustrated by an asterisk next to the mean math score with the following representations: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$. The descriptive statistics will first assess the data at the national level for grade four and grade eight, illustrating the overall ways that technology affects standardized math scores on the NAEP. Next the analysis will provide insight into patterns of access, student home usage, student classroom usage, teacher classroom usage and teacher computer competency for Large Cities and the four TUDAs: Chicago, Boston, D.C. and Miami.

National Descriptive Analysis.

Table 9 and Table 10 provides the next level of analysis -- comparing the means and frequencies, giving insight into patterns and disparities among demographic variables that are particularly important to this research. Both grade four and grade eight descriptive statistics at the national level illustrate statistically significant disparities in mean test scores by gender, race, income and parent educational level.

Demographic Disparities: For grade four the biggest disparities existed for those who were eligible for free and reduced lunch (M=228.63, SD=26.14) compared to those who were not eligible (M=251.77, SD=24.47) conditions; $t(198,278)$ 202.116, $p<0.001$. Racial disparities also exist in grade four: blacks scored the lowest (M=221.87, SD=25.26), compared to Hispanics (M=229.17, SD=26.11), and whites (M=248.10, SD=24.70). There was a significant effect at the $p<0.001$ level for the three racial conditions [$F(5, 198,882) = 7,630$, $p<0.001$].

The largest grade eight demographic disparities existed between minorities and whites, and between different parent educational level. Blacks scored the lowest (M=260.10, SD=31.23), compared to Hispanics (M=268.67, SD=32.33), and whites (M=292.00, SD=31.30). There was a significant effect at the $p<0.001$ level for the three racial conditions [$F(5, 164,402) = 6,004$, $p = 0.000$]. Parent education level significantly correlated with achievement levels for students in grade eight. Students who lived with a parent who did not finish high school had a lower score (M=264.59, SD=30.68) compared to parents who graduated from high school (M=268.93, SD=31.78), and those who graduated from college (M=292.56, SD=34.04), which were all significant at the $p<0.001$ level for the parent educational level conditions [$F(3, 142,468) = 5,197.10$, $p = 0.000$]. Demographic differences in mean test scores suggest that gender, race, income and parent educational level significantly influence student standardized test scores.

Home and School Access: At the national level a majority of students responded that they had access to a computer at home and at school; specifically 84.7 percent of grade four and 87.8 percent of grade eight students reported having a computer at home, and 88.5 percent of grade four classrooms and 88.4 percent of grade eight reported having a computer in their math classroom. An independent-samples t-test was conducted to compare the NAEP math score in access and no access conditions at both the home and school levels. Home access seem to have a more significant impact on student scores, than school access. For grade four there was a significant difference in the scores for home access (M=240.95, SD=27.56) and no home access (M=226.97, SD=26.73) conditions; $t(195{,}124)$ -71.66, $p<0.001$. Grade eight also illustrated a significant difference in math scores for home access (M=283.16, SD=34.47) , compared to those students who did not have home access (M=261.05, SD=32.19) conditions; $t(160{,}746)$ -69.30, $p<0.001$. These results suggest that students with home and school access to computer technology can positively impact their student math scores.

Student Reported Home Computer Usage: A majority of students in both grade four and grade eight reported using their computer at home; however, when asked if they used the computer for math homework a majority responded they did not (i.e. 78 percent of grade four and 80 percent of grade eight). Students who used the computer for general internet reasons (not related to math) seemed to have higher math score in both grade four and grade eight; however, students who use the computer specifically for math homework had lower scores.

For grade four there was a significant difference in the scores of students who used the internet at home (M=242.20, SD=27.36) and who did not use the internet at home (M=227.57, SD=27.58) conditions; $t(180{,}717)$ -83.89, $p<0.001$. Similarly for grade eight there was a significant difference in the scores of students who used the internet at home (M=284.0, SD=34.20) and those who did not (M=263.45, SD=33.23) conditions; t(153,816) -65.45, p<0.001. This provides insight into the patterns of home computer usage, and findings reveal that in general students who use the internet at home have higher test scores, while for students who use the computer for math purposes, their scores are likely to decrease. Grade eight students received two additional questions and results indicate that those students who used the computer at home for e-mail/messaging/blogging to get math help from friends had higher scores (M=284.75, SD=35.46) compared to those who did not use it (M=280.55, SD=33.90) conditions; t(153,161) -23.37, p<0.001. This association was probably the result of students using social communication technologies to communicate with their peers regarding their math assignments and questions that pertain to math homework.

Student Reported Classroom Computer Usage: While students in both grades reported similar responses to access and home computer usage classroom usage differed based on grade level. Grade four math classrooms typically used the computer less, with 53 percent responding they never used the computer. When they did use the computer it was more often for didactic approaches to “practice or drill on math facts” (46 percent responded yes) compared to other approaches. Students who used this approach scored slightly higher (M=240.23, SD=28.16), compared to those who did not (M=238.64, SD=27.51) conditions; t(194,669) 12.52, p<0.001. Students who reported “using the internet to learn about things related to math,” a constructivist approach had lower test scores (M=236.76, SD=28.26) compared to those that did not use this application (M=241.65, SD=27.23) conditions; t(194,523) 38.855, p=0.000.

A little over a quarter (29 percent) of students in grade eight reported using the computer at school for math. The more common approaches to classroom usage for grade eight included constructivist approaches that "use computer program for new lessons on problem solving" (40 percent) and "use the internet to learn things for math class" (36 percent), and didactic "using the computer to drill on math facts" (37 percent). While grade four students who used didactic approaches (i.e. "to drill on math facts") improved their scores, grade eight students who reported using this approach had lower scores (M= 268.13, SD=33.79) compared to those who did not (M=290.85, SD=32.367) conditions, t(157,885) 27.614, $p<0.001$. Furthermore, all grade eight students who reported "yes" to using computers for any type of approach (didactic or constructivist) had significantly lower test scores that those who did not use technology, at the $p<0.001$ level. These findings illustrate the way that technology affects math scores is different in grade four and grade eight based on the type of programs that are utilized within the classroom.

Teacher Classroom Computer Usage: The majority of grade four math teachers who used computer technology in the classrooms at least once a month reported using it for didactic purposes, with 78 percent using it to "practice/review math", and 82 percent "to play math games." Constructivist approaches were less commonly used by grade four teachers as only 24 percent reported using it so students could "research a math topic," and 22 percent "to draw geometric shapes." While all t-tests illustrated statistically significant differences in grade four mean math scores, no approach illustrated increases or decreases of +/- 2 points on the NAEP math exam.

Similar to grade four, teachers in grade eight math classrooms reported using didactic approaches more often than constructivist approaches. For example, roughly half of all students used the computer for didactic approaches to “practice or review math” and/or “to play math games,” while less than 25 percent used it for constructivist approaches such as “research a math topic” (19 percent), “draw geometric shapes” (14 percent), “graphing computer program” (25 percent), and “email about math” (24 percent). However, students of grade eight math teachers who reported using didactic approaches had significantly lower math scores than those who did not. For example, students who used the computer “to play math games” scored lower (M= 278.44, SD=34.89) compared to those who did not use this approach (M=285.30, SD=34.04) conditions; t(147,998) 38.196, $p<0.001$, while teachers who used three out of the five constructivist approaches were more likely to have students score higher. Constructivist approaches that were more likely to correlate with increased test scores included students who used the computer to draw geometric shapes, use graphing programs, and/or to email about math. Teachers who reported having students use the computer for constructivist approaches to extend math learning, and research a math topic had a decline in scores of 2.66 and 3.80 respectively.

Teacher Computer Competency: Overall teacher computer competency variables strongly correlate with math NAEP exam results for grade four and grade eight. Although the results were statistically significant for all variables, the change in math scores from those who answered “yes” to having computer training compared to those who answered “no” was only 1 to 3 points. The largest statistical difference between means was illustrated with grade four math teachers. Teachers whom responded “yes” to training in basic computers had students who scored higher (M=239.75, SD=27.71), compared to those who answered “no (M=236.89, SD=28.288) conditions; t(189,553) -14.643, $p<0.001$. These findings might suggest that computer training and professional development on computer technology might support student academic learning environments.

Table 9: Descriptive Statistics - Grade Four National T-Test

NAEP Variables	N	Mean Standardized Test Score	Std Dev
Overall	198,888	239.23	27.887
Gender			
Male	101,107	239.88***	28.715
Female	97,781	238.55***	26.988
Race			
White	106,721	248.1***	24.698
Black	34,294	221.87***	25.258
Hispanic	39,531	229.17***	26.109
Socio-economic Status			
Not Eligible for Lunch Program	90,740	251.77***	24.471
Eligible for Lunch Program	107,540	228.63***	26.139
Home Access			
Computer in home			
No, computer in the home	22,381	226.97***	26.734
Yes, computer in the home	172,745	240.95***	27.558
School Access			
Pct classrooms w/computer: gr 4 math			
0 to 99 percent	11,502	234.80***	28.625
100 percent	176,182	239.81***	27.769
Pct classrooms with Internet: gr 4 math			
0 to 99 percent	56,969	239.78***	28.183
100 percent	130,287	239.38***	27.709
Handheld devices (e.g., PDAs)			
0 to 99 percent	106,627	239.73***	27.905
100 percent	80,034	239.27***	27.761
Student Home Usage			
Use the Internet at home			
No, I do not use the internet	29,479	227.57***	27.575
Yes, I do use the internet	151,240	242.20***	27.350
Use computer at home for math homework			
No, I do not use the computer	151,340	241.18***	27.122

Yes, I do use the computer	42,846	233.13***	29.277
Student Classroom Usage			
Use computer at school for math			
Never or hardly ever	104,203	242.03***	26.752
At least once a month or more	90,670	236.29***	28.701
Didactic: Use computer to practice or drill on math			
No, I do not use	105,935	238.64***	27.510
Yes, I do use	88,736	240.23***	28.155
Didactic: Use computer to play math games			
No, I do not use	146,257	239.40***	27.718
Yes, I do use	48,256	239.32***	28.120
Constructivist: Use computer to make charts or graphs for math			
No, I do not use	160,100	241.04***	26.935
Yes, I do use	32,836	231.57***	30.582
Constructivist: Use the Internet to learn things about math			
No, I do not use	104,049	241.65***	27.232
Yes, I do use	90,476	236.76***	28.256
Teacher Classroom Usage			
Availability of computers for teacher/students			
No, availability	1,272	231.56***	28.956
Yes, availability	183,458	239.66***	27.738
Didactic: Students use computer to practice/review math			
Never or hardly ever	39,749	239.59***	28.567
At least once a month or more	144,873	239.60***	27.532
Didactic: Students use computer to play math games			
Never or hardly ever	32,607	238.85***	28.382
At least once a month or more	151,998	239.76***	27.613
Constructivist: Students use computer to extend math learning			
Never or hardly ever	53,470	240.13***	27.954
At least once a month or more	131,070	239.39***	27.670
Constructivist: Students use computer to research a math topic			
Never or hardly ever	140,206	239.99***	27.594
At least once a month or more	44,289	238.38***	28.216
Constructivist: Students use computer to draw geometric shapes			
Never or hardly ever	143,808	239.66***	27.702

At least once a month or more	40,507	239.42***	27.919
Teacher Computer Competency			
Prof dev-use of computers or other technology			
Not at all or very small extent	122,627	239.76***	27.858
Moderate to Large extent	66,866	238.77***	27.632
Training in basic computers			
No, I have not received training	23,177	236.89***	28.287
Yes, I have received training or I am already proficient	166,378	239.75***	27.710
Training in software applications			
No, I have not received training	53,265	237.93***	27.941
Yes, I have received training or I am already proficient	135,944	239.98***	27.720
Training in use of the Internet			
No, I have not received training	27,782	238.17***	28.050
Yes, I have received training or I am already proficient	160,867	239.64***	27.749
Training in use of other technology			
No, I have not received training	80,726	238.29***	28.025
Yes, I have received training or I am already proficient	108,517	240.25***	27.582
Training in integrating computers into instruction			
No, I have not received training	34,151	236.83***	28.482
Yes, I have received training or I am already proficient	155,236	239.96***	27.609

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

Table 10: Descriptive Statistics - Grade Eight National T-Test

NAEP Variables	N	Mean Standardized Test Score	Std Dev
Overall	164,403	281.38***	34.865
Gender			
Male	83,305	281.78***	35.756
Female	81,098	280.98***	33.921
Race			
White	90,224	292.00***	31.293
Black	29,846	260.10***	31.229
Hispanic	29,844	268.67***	32.333
Socio-economic Status			
Not Eligible for Lunch Program	81,957	294.90***	31.958
Eligible for Lunch Program	81,778	267.87***	32.272
Parent Education Level			
Did not finish high school	12,455	264.59***	30.675
Graduated high school	27,677	268.93***	31.779
Some education after high school	26,514	282.97***	29.895
Graduated college	75,826	292.56***	34.037
Home Access			
Computer in home			
No, computer in the home	12,533	261.05***	32.186
Yes, computer in the home	148,215	283.16***	34.471
School Access			
Availability of computers for teachers students			
No, I do not have access	1,229	277.66***	37.878
Yes, I do have access	147,186	282.16***	34.585
Student Home Usage			
Use the Internet at home			
No, I do not use the internet	12,890	263.45***	33.231
Yes, I do use the internet	140,928	284.00***	34.198
Use computer at home for math homework			
No, I do not use the computer	127,548	282.36***	34.408

Yes, I do use the computer	32,474	278.75***	35.874
Use email/message/blog-get math help			
No, I do not use the computer	86,201	287.91***	33.643
Yes, I do use the computer	65,579	275.22***	34.256
Use email/message/blog-get math help with friends			
No, I do not use the computer	91,541	280.55***	33.907
Yes, I do use the computer	61,622	284.75***	35.458
Student Classroom Usage			
Use computer at school for math			
Never or hardly ever	113,697	284.16***	33.845
At least once a month or more	46,190	275.46***	36.108
Time per day spent on computer			
None	87,159	286.90***	34.054
Half an hour or more	72,620	275.37***	34.492
Use calculator computer program for math class			
No, I do not use	94,557	285.88***	32.833
Yes, I do use	61,946	276.53***	36.173
Didactic: Use computer program to drill on math facts			
No, I do not use	99,971	290.05***	32.367
Yes, I do use	57,916	268.13***	33.788
Constructivist: Use spreadsheet program for math assignments			
No, I do not use	117,522	287.73***	32.776
Yes, I do use	40,629	265.11***	34.304
Constructivist: Use computer program for new lessons on problem solving			
No, I do not use	94,038	289.70***	32.317
Yes, I do use	63,488	270.66***	34.649
Constructivist: Use internet to learn things for math class			
No, I do not use	100,755	286.40***	32.761
Yes, I do use	56,399	274.35***	36.270
Constructivist: Use graphing program for charts for math class			
No, I do not use	115,703	286.57***	32.489
Yes, I do use	40,700	269.67***	36.978
Constructivist: Use statistical computer program for math class			
No, I do not use	125,608	287.55***	32.475
Yes, I do use	30,430	260.09***	33.884
Constructivist: Use word computer processing program for math class			

No, I do not use	118,435	287.57***	32.108
Yes, I do use	37,528	265.21***	36.304
Teacher Classroom Usage			
Students use computer for four function calculator			
Never or hardly ever	74,089	283.69***	34.329
At least once a month or more	73,741	280.62***	34.810
Student use computer use scientific calculator			
Never or hardly ever	66,230	279.18***	35.179
At least once a month or more	81,783	284.61***	33.938
Students use computer use graphing calculator			
Never or hardly ever	86,155	278.67***	34.181
At least once a month or more	61,823	287.05***	34.580
Didactic: Students use computer practice or review math			
Never or hardly ever	73,344	284.06***	34.025
At least once a month or more	74,742	280.31***	35.079
Didactic: Students use computer to play math games			
Never or hardly ever	80,832	285.30***	34.037
At least once a month or more	67,168	278.44***	34.889
Constructivist: Students use computer extend math learning			
Never or hardly ever	81,359	283.88***	33.902
At least once a month or more	66,529	280.08***	35.321
Constructivist: Students use computer research a math topic			
Never or hardly ever	119,827	282.68***	34.352
At least once a month or more	28,293	280.03***	35.535
Constructivist: Students use computer to draw geometric shapes			
Never or hardly ever	127,957	282.05***	34.285
At least once a month or more	20,055	283.01***	36.546
Constructivist: Students use computer use for graphing program			
Never or hardly ever	110,920	280.50***	34.367
At least once a month or more	36,888	287.25***	34.820
Constructivist: Students use computer email about math			
Never or hardly ever	111,729	280.48***	34.415
At least once a month or more	36,171	287.47***	34.624
Teacher Computer Competency			
Prof dev-use of computers or other technology			

Not at all or very small extent	25,101	281.16***	34.545
Moderate to Large extent	123,564	282.29***	34.612

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

Large City and TUDA Descriptive Analysis.

This study also examines differences in access, usage and teacher computer competency across different school types, and this section examines how differences are seen at the Large City (LC) and TUDA level. For each analysis, I provide two tables per grade level to examine the univariate relationships that occur between technology and student achievement. The first table in each section provides a summary of the students' achievement and indicates if there was a correlation between the technology intervention, and student standardized scores. Student scores that were correlated with a positive increase had a "+" representation, while negative correlations were represented with a "-" sign. The second table provides more specific details on the mean scores, standard deviations, and significance level for students in Large Cities and in the following four TUDAs: Chicago, Washington, D.C., Boston and Miami. Furthermore, these results are only a univariate relationship, and the major point of these findings is to illustrate that the relationships vary from TUDA to TUDA.

Access: Following the trends at the national level, Large City and TUDAs seem to have relatively high levels of access to computers in the home and at school, with the exception of schools having handheld devices. Corresponding with the national trends for both grade four and grade eight, access to computers in the home and at school play a significant part in increased mean scores on the NAEP exam with the exception of a few school-access variables. More specifically, both grade four and grade home access was highly correlated with improved math scores for all LC and TUDA regions.

Home access had consistent results across grade levels; however, school access had different effects on scores based on school location. In grade four classrooms, “percent of classrooms with a computer” was correlated with improved scores for LCs, Chicago, and D.C.; however, it was correlated with decreased scores in Boston and Miami. Similarly, “the percent of classrooms with the internet” was correlated with increased scores for LC, Chicago , D.C. and also Miami; however, it decreased scores in Boston. In grade eight, “the availability of computers for teachers and student” improved scores in LCs, Chicago and Miami[5], while correlated with decreased scores for students in D.C. and Boston. Although these scores are univariate, the results might indicate that having access to a home and school computer might increase test scores in grade four and grade eight for most urban areas; however, in some urban areas it can hinder performance.

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5. Miami not statistically significant

Table 11: Summary of Home and School Access: Grade Four National, Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Computer in Home	+	+	+	+	+	+
Pct classrooms w/ computer: gr 4 math	+	+	+	+	-	-
Pct classrooms with Internet: gr 4 math	+	+	+	+	-	+
Handheld devices (e.g., PDAs)	+	+	+	+	-	Not Significant

Table 12: Home and School Access: Grade Four Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	7,239	15%	221.49***	26.525
Yes, computer in the home	42,055	85%	233.35***	29.019
Pct classrooms w/computer: gr 4 math				
0 to 99 percent	4,773	10%	228.96***	28.687
100 percent	41,551	90%	232.28***	29.121
Pct classrooms with Internet: gr 4 math				
0 to 99 percent	3,933	9%	230.83**	28.852
100 percent	42,311	91%	232.07**	29.119
Handheld devices (e.g., PDAs)				
0 to 99 percent	27,374	60%	231.80**	28.995
100 percent	18,588	40%	232.36**	29.210

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	374	16%	214.10***	26.716
Yes, computer in the home	1,979	84%	225.46***	28.183
Pct classrooms w/computer: gr 4 math				
0 to 99 percent	256	12%	215.12***	25.351

100 percent	1,862	88%	224.25***	28.992
Pct classrooms with Internet: gr 4 math				
0 to 99 percent	133	6%	214.48***	22.617
100 percent	1,985	94%	223.73***	29.001
Handheld devices (e.g., PDAs)				
0 to 99 percent	1,189	58%	222.91***	28.053
100 percent	877	42%	223.28***	29.415

District of Colombia

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	188	14%	208.60***	30.180
Yes, computer in the home	1,153	86%	225.32***	35.989
Pct classrooms w/computer: gr 4 math				
0 to 99 percent	171	15%	214.48***	31.215
100 percent	959	85%	222.51***	36.135
Pct classrooms with Internet: gr 4 math				
0 to 99 percent	273	24%	212.28***	31.022
100 percent	857	76%	224.16***	36.411
Handheld devices (e.g., PDAs)				
0 to 99 percent	668	59%	220.34*	34.290
100 percent	462	41%	222.67*	37.264

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	209	12%	229.00***	22.458
Yes, computer in the home	1,472	88%	238.99***	26.089
Pct classrooms w/computer: gr 4 math				
0 to 99 percent	720	45%	240.20***	25.623
100 percent	877	55%	236.09***	26.189
Pct classrooms with Internet: gr 4 math				
0 to 99 percent	1,050	66%	238.65**	25.844
100 percent	547	34%	236.57**	26.288
Handheld devices (e.g., PDAs)				
0 to 99 percent	890	57%	238.43	25.054
100 percent	681	43%	237.10	27.387

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	208	8%	224.11***	26.942
Yes, computer in the home	2,383	92%	235.72***	26.487
Pct classrooms w/computer: gr 4 math				
0 to 99 percent	192	8%	236.17	22.426
100 percent	2,192	92%	235.14	27.095
Pct classrooms with Internet: gr 4 math				
0 to 99 percent	827	35%	232.21***	25.561
100 percent	1,557	65%	236.82***	27.228
Handheld devices (e.g., PDAs)				
0 to 99 percent	1,706	73%	234.54	26.922
100 percent	635	27%	236.02	26.299

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 13: Summary of Home and School Access: Grade Eight National, Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Computer in Home	+	+	+	+	+	+
Availability of computers for teachers students	+	+	+	-	-	Not Significant

Table 14: Home and School Access: Grade Eight Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	4,185	10%	253.31***	31.682
Yes, computer in the home	36,110	90%	273.24***	35.855

Availability of computers for teachers students				
No, I do not have access	483	1%	270.86**	40.293
Yes, I do have access	35,481	99%	272.25**	36.009

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	194	10%	258.19***	28.967
Yes, computer in the home	1,772	90%	271.49***	32.533
Availability of computers for teachers students				
No, I do not have access	16	1%	255.14*	25.402
Yes, I do have access	1,540	99%	271.75*	31.892

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	154	12%	237.14***	34.557
Yes, computer in the home	1,130	88%	260.12***	39.637
Availability of computers for teachers students				
No, I do not have access	50	4%	262.33*	34.298
Yes, I do have access	1,072	96%	258.33*	40.820

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	74	6%	263.05***	31.653
Yes, computer in the home	1105	94%	279.52***	36.584
Availability of computers for teachers students				
No, I do not have access	56	6%	301.98**	55.711
Yes, I do have access	938	94%	279.53**	35.008

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Computer in home				
No, computer in the home	141	6%	253.03***	26.815
Yes, computer in the home	2,371	94%	272.97***	33.336
Availability of computers for teachers students				
No, I do not have access	2	0%	264.90	7.386
Yes, I do have access	2,223	100%	271.44	33.760

* $p < .05$; ** $p < .01$; *** $p < .001$

Student Home Usage: Table 16 displays the association between student reported home usage variables and math achievement for grade four and grade eight students. Overall, the effect of "using the internet at home" illustrated a positive increase in math scores for both grade four and grade eight LCs and TUDAs. The pattern indicated that when students used the internet at home more than once a week, they displayed the highest math performance. More specifically, grade four students in Miami who use the internet at home had the highest difference in scores (M=237.24, SD=26.105) compared to those who did not (M=223.15, SD=27.94) conditions; t(2,370) -7.99, p<0.001. Similarly, grade eight students in D.C. also reported higher scores when using the internet at home (M=260.67, SD=39.65) compared to those who did not (M=235.97, SD=36.60) conditions; t(1,185) -6.189, p<0.001.

Although using the internet statistically correlated to improved test scores, students who reported using the computer at home for "math homework" had decreased test scores for both grade four and grade eight; as well as using the computer for email/message/blog to get math help for grade eight only. The results highlight the finding that internet use for math purposes for grade four and grade eight students was negatively associated with math performance.

Table 15: Summary of Student Reported Home Usage: Grade Four National, Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Use the Internet at home	+	+	+	+	+	+
Use computer at home for math homework	-	-	-	-	-	-

Table 16: Student Reported Home Usage: Grade Four Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	8,678	19%	221.25***	27.352
Yes, I do use the internet	36,824	81%	234.66***	28.894
Use computer at home for math homework				
No, I do not use the computer	36,280	74%	233.97***	28.307
Yes, I do use the computer	12,740	26%	225.04***	29.821

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	426	20%	213.97***	27.119
Yes, I do use the internet	1,732	80%	226.85***	28.098
Use computer at home for math homework				
No, I do not use the computer	1,641	70%	226.23***	27.536

Yes, I do use the computer	708	30%	217.51***	29.045

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	206	17%	206.72***	33.673
Yes, I do use the internet	992	83%	226.57***	35.583
Use computer at home for math homework				
No, I do not use the computer	887	66%	226.12***	36.341
Yes, I do use the computer	448	34%	216.92***	33.656

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	231	15%	229.17***	24.437
Yes, I do use the internet	1,325	85%	239.54***	26.082
Use computer at home for math homework				
No, I do not use the computer	1,232	74%	239.78***	25.164
Yes, I do use the computer	442	26%	232.38***	26.975

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	249	10%	223.15***	27.937
Yes, I do use the internet	2,123	90%	237.24***	26.105
Use computer at home for math homework				
No, I do not use the computer	1,783	69%	236.74***	26.775
Yes, I do use the computer	794	31%	230.70***	26.045

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

Table 17: Summary of Student Reported Home Usage: Grade Eight National, Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Use the Internet at home	+	+	+	+	+	+
Use computer at home for math homework	-	-	-	-	Not Significant	Not Significant

Use email/message/blog-get math help	-	-	-	-	-	-
Use email/message/blog-get math help with friends	+	+	+	+	Not Significant	+

Table 18: Student Reported Home Usage: Grade Eight Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	3,622	10%	254.84***	32.814
Yes, I do use the internet	33,750	90%	274.21***	35.703
Use computer at home for math homework				
No, I do not use the computer	30,007	75%	272.09***	35.781
Yes, I do use the computer	9,842	25%	269.50***	36.218
Use email/message/blog-get math help				
No, I do not use the computer	18,648	51%	279.30***	35.263
Yes, I do use the computer	18,007	49%	265.67***	34.884
Use email/message/blog-get math help with friends				
No, I do not use the computer	20,771	56%	270.37***	34.942
Yes, I do use the computer	16,380	44%	274.71***	36.947

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	179	10%	258.57***	30.627
Yes, I do use the internet	1,647	90%	272.80***	32.327
Use computer at home for math homework				
No, I do not use the computer	1,521	78%	271.29**	32.361
Yes, I do use the computer	430	22%	267.03**	32.305
Use email/message/blog-get math help				
No, I do not use the computer	812	45%	278.33**	32.841
Yes, I do use the computer	973	55%	265.85***	31.141
Use email/message/blog-get math help with friends				
No, I do not use the computer	783	43%	269.39*	32.093
Yes, I do use the computer	1,029	57%	272.88*	32.696

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	107	9%	235.97***	36.603
Yes, I do use the internet	1,080	91%	260.67***	39.649
Use computer at home for math homework				
No, I do not use the computer	937	74%	259.19**	39.726
Yes, I do use the computer	332	26%	252.84**	39.670
Use email/message/blog-get math help				
No, I do not use the computer	618	53%	267.09***	40.309
Yes, I do use the computer	551	47%	250.42***	36.770
Use email/message/blog-get math help with friends				
No, I do not use the computer	650	55%	257.15*	39.127
Yes, I do use the computer	538	45%	260.08*	40.838

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	74	7%	260.34***	37.047
Yes, I do use the internet	1011	93%	281.84***	35.550
Use computer at home for math homework				
No, I do not use the computer	857	75%	279.56	35.722
Yes, I do use the computer	293	25%	278.27	38.156
Use email/message/blog-get math help				
No, I do not use the computer	502	48%	288.40***	36.568
Yes, I do use the computer	552	52%	274.48***	33.906
Use email/message/blog-get math help with friends				
No, I do not use the computer	504	47%	281.17	36.164
Yes, I do use the computer	569	53%	279.92	36.148

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use the Internet at home				
No, I do not use the internet	149	6%	251.42***	31.951
Yes, I do use the internet	2,222	94%	273.97***	32.962
Use computer at home for math homework				

No, I do not use the computer	1,501	60%	272.76	33.353
Yes, I do use the computer	1,004	40%	270.92	32.955
Use email/message/blog-get math help				
No, I do not use the computer	1,078	46%	280.63***	32.528
Yes, I do use the computer	1,257	54%	266.30***	32.040
Use email/message/blog-get math help with friends				
No, I do not use the computer	1,239	52%	271.00**	32.070
Yes, I do use the computer	1,122	48%	274.55**	34.324

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

Student Classroom Usage Grade Four: Roughly half of all grade four LC and TUDA students used the computer at school for math. Results indicated that students who reported using the computer "at least once a month or more" scored lower on the NAEP math section in LCs and all TUDAs, particularly in D.C. and Miami where those students reporting they used the computer in the classroom scored at least 10 points lower, compared to those who did not. This compared to the national trends, when a one-way between subjects ANOVA was conducted to compare the effect of time spent on the computer at school with mean test scores. There was a significant effect on the amount of time spent on the computer at the $p<0.001$ level for the five conditions [$F(4, 194{,}868) = 1213.76$, $p<0.001$]. Post hoc comparisons using the Bonferroni test indicated that the mean score for students who "never or hardly ever" used the computer at school ($M=242.03$, $SD=26.75$) was significantly lower than those who used the computer "almost every day" ($M=226.65$, $SD=29.80$). Taken together, these results suggest that at the national, LC and TUDA schools, overall student reported computer usage had a negative effect on standardized math scores on the NAEP at the fourth grade level.

Table 19: Summary of Student Reported Classroom Usage: Grade Four Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Use computer at school for math	-	-	-	-	-	-
Didactic: Use computer to practice or drill on math	+	+	Not Significant	Not Significant	+	Not Significant
Didactic: Use computer to play math games	-	+	+	-	-	Not Significant
Constructivist: Use computer to make charts or graphs for math	-	-	-	-	-	-
Constructivist: Use the Internet to learn things about math	-	-	-	-	Not Significant	Not Significant

Table 20: Student Reported Classroom Usage: Grade Four Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	24,144	49%	235.53***	28.464
At least once a month or more	25,074	51%	227.82***	28.965
Didactic: Use computer to practice or drill on math				
No, I do not use	25,650	52%	231.37***	28.684
Yes, I do use	23,524	48%	231.89***	29.276
Didactic: Use computer to play math games				
No, I do not use	37,229	76%	231.55***	28.786
Yes, I do use	11,903	24%	231.90***	29.554
Constructivist: Use computer to make charts or graphs for math				

No, I do not use	38,598	79%	233.70***	28.060
Yes, I do use	10,147	21%	224.00***	30.962
Constructivist: Use the Internet to learn things about math				
No, I do not use	23,150	47%	234.16***	28.900
Yes, I do use	25,978	53%	229.39***	28.846

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	1,142	49%	229.51***	27.245
At least once a month or more	1,209	51%	217.96***	28.078
Didactic: Use computer to practice or drill on math				
No, I do not use	1,161	49%	223.96	29.212
Yes, I do use	1,187	51%	223.35	27.198
Didactic: Use computer to play math games				
No, I do not use	1,687	72%	223.49***	28.205
Yes, I do use	663	28%	224.01***	28.255
Constructivist: Use computer to make charts or graphs for math				
No, I do not use	1,768	76%	225.78***	27.506
Yes, I do use	567	24%	216.87***	29.622
Constructivist: Use the Internet to learn things about math				
No, I do not use	979	42%	225.11***	28.284
Yes, I do use	1,366	58%	222.52***	28.148

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	596	45%	230.28***	37.044
At least once a month or more	743	55%	217.00***	33.584
Didactic: Use computer to practice or drill on math				
No, I do not use	652	49%	224.32	37.181
Yes, I do use	685	51%	221.59	34.207
Didactic: Use computer to play math games				
No, I do not use	328	25%	228.99***	37.069
Yes, I do use	1,008	75%	221.13***	35.065
Constructivist: Use computer to make charts or graphs for math				
No, I do not use	978	75%	226.36***	35.008

Yes, I do use	334	25%	213.55***	35.569
Constructivist: Use the Internet to learn things about math				
No, I do not use	560	42%	229.51***	36.576
Yes, I do use	777	58%	218.39***	34.368

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	832	50%	241.81***	25.974
At least once a month or more	845	50%	233.89***	25.124
Didactic: Use computer to practice or drill on math				
No, I do not use	799	48%	235.15**	25.514
Yes, I do use	873	52%	240.25**	25.913
Didactic: Use computer to play math games				
No, I do not use	1,308	78%	238.57***	25.374
Yes, I do use	366	22%	235.22***	27.211
Constructivist: Use computer to make charts or graphs for math				
No, I do not use	1,416	85%	239.52***	25.574
Yes, I do use	243	15%	228.01***	25.225
Constructivist: Use the Internet to learn things about math				
No, I do not use	802	48%	238.83	25.455
Yes, I do use	869	52%	237.04	26.185

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	848	33%	241.46***	26.471
At least once a month or more	1,740	67%	231.60***	26.232
Didactic: Use computer to practice or drill on math				
No, I do not use	1,094	42%	234.90	26.572
Yes, I do use	1,489	58%	234.84	26.792
Didactic: Use computer to play math games				
No, I do not use	456	18%	235.25	28.417
Yes, I do use	2,127	82%	234.77	26.349
Constructivist: Use computer to make charts or graphs for math				
No, I do not use	2,006	78%	236.43***	25.917
Yes, I do use	558	22%	230.01***	28.531

Constructivist: Use the Internet to learn things about math				
No, I do not use	1,020	39%	237.02	27.863
Yes, I do use	1,565	61%	233.46	25.834

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

Student Classroom Usage Grade Eight: Although grade four students' scores went down when they used the computer, one didactic approach "to practice or drill on math" improved scores in LCs and in Boston; however, had no effect in Chicago, D.C. or Miami. Boston students who reported using this approach scored significantly higher (M=240.25, SD=25.913) compared to those who did not (M=235.15, SD=25.514) conditions; t(1,661) 4.05, p<0.01. These results might indicate that students' self-reported technology usage in grade four might not have a broad positive impact in all urban areas; rather investigation into specific locations is necessary to determine if it is useful to improve scores serving a particular population.

Between 30 to 40 percent of all LC and TUDA grade eight students reported using a classroom computer for math more than once a month, which was substantially less than grade four students. There was a significant relationship between students who used the computer and lower scores on NAEP at the national, LC, and TUDA levels. Boston had the most significant drop in scores as students who reported "never or hardly ever" using the computer at school for math had higher math scores (M=285.56, SD=36.26), compared to those who used it more than once a month (M=265.44, SD=265.44) conditions; t(1,144) 8.921, p<0.001.

Furthermore, using either didactic and/or constructivist approaches was associated with substantial decreases in scores across all LCs, and TUDAs. Drill and practice didactic approaches negatively affected the students the most compared to all other approaches. Particularly, students in LCs who used this approach had a lower mean score (M=259.54, SD=33.603) compared to those who did not use this approach (M=282.15, SD=34.102) conditions; t(38,843) 65.30, p<0.001. Boston students also saw dramatic decreases in scores, as students who responded they use this approach scored substantially lower (M=267.20, SD=33.896) compared to those who did not use it (M=289.51, SD=34.235) conditions; t(1,096) 10.613, p<0.001. These results may indicate that while using didactic approaches for grade four improved scores in LCs and in Boston, the same "drill and practice" approach does not adequately work in grade eight.

Table 21: Summary of Student Reported Classroom Usage: Grade Eight Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Use computer at school for math	-	-	-	-	-	-
Time per day spent on computer	-	-	-	-	-	-
Use calculator computer program for math class	-	-	Not Significant	-	Not Significant	-
Didactic: Use computer program to drill on math facts	-	-	-	-	-	-
Constructivist: Use spreadsheet program for math assignments	-	-	-	-	-	-
Constructivist: Use computer program for new lessons on problem solving	-	-	-	-	-	-

Constructivist: Use internet to learn things for math class	-	-	-	-	-	-
Constructivist: Use graphing program for charts for math class	-	-	-	-	-	-
Constructivist: Use statistical computer program for math class	-	-	-	-	-	-
Constructivist: Use word computer processing program for math class	-	-	-	-	-	-

Table 22: Student Reported Classroom Usage: Grade Eight Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	26,734	67%	274.77***	35.393
At least once a month or more	13,137	33%	264.71***	35.979
Time per day spent on computer				
None	18,983	48%	276.78***	36.320
Half an hour or more	20,728	52%	266.68***	34.837
Use calculator computer program for math class				
No, I do not use	21,857	57%	277.27	34.294
Yes, I do use	16,437	43%	265.84	36.366
Didactic: Use computer program to drill on math facts				
No, I do not use	21,578	56%	282.15***	34.102
Yes, I do use	17,267	44%	259.54***	33.603
Constructivist: Use spreadsheet program for math assignments				
No, I do not use	26,462	68%	279.76***	34.222
Yes, I do use	12,508	32%	255.46***	33.357
Constructivist: Use computer program for new lessons on problem solving				
No, I do not use	20,252	52%	281.69***	34.047
Yes, I do use	18,443	48%	261.63***	34.546
Constructivist: Use internet to learn things for math class				
No, I do not use	21,576	56%	278.08***	34.293

Yes, I do use	16,989	44%	264.68***	36.078
Constructivist: Use graphing program for charts for math class				
No, I do not use	26,226	69%	278.41***	33.778
Yes, I do use	12,001	31%	258.94***	36.131
Constructivist: Use statistical computer program for math class				
No, I do not use	28,459	75%	279.40***	33.779
Yes, I do use	9,615	25%	251.42***	32.931
Constructivist: Use word computer processing program for math class				
No, I do not use	26,272	69%	279.74***	33.231
Yes, I do use	11,773	31%	255.86***	35.577

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	1,312	67%	273.98***	31.906
At least once a month or more	641	33%	262.79***	32.149
Time per day spent on computer				
None	873	45%	278.22***	31.183
Half an hour or more	1,075	55%	263.93***	32.057
Use calculator computer program for math class				
No, I do not use	1,033	55%	277.42	31.097
Yes, I do use	848	45%	263.50	31.894
Didactic: Use computer program to drill on math facts				
No, I do not use	980	51%	282.06***	30.795
Yes, I do use	927	49%	259.09***	29.554
Constructivist: Use spreadsheet program for math assignments				
No, I do not use	1,205	63%	278.40***	31.547
Yes, I do use	707	37%	257.61***	29.483
Constructivist: Use computer program for new lessons on problem solving				
No, I do not use	911	48%	282.06***	31.101
Yes, I do use	992	52%	260.69***	29.876
Constructivist: Use internet to learn things for math class				
No, I do not use	996	52%	277.85***	30.618
Yes, I do use	903	48%	263.35***	32.459
Constructivist: Use graphing program for charts for math class				
No, I do not use	1,236	66%	276.95***	31.067
Yes, I do use	647	34%	260.15***	31.843

Constructivist: Use statistical computer program for math class				
No, I do not use	1,351	72%	277.72***	30.705
Yes, I do use	520	28%	254.19***	30.316
Constructivist: Use word computer processing program for math class				
No, I do not use	1,226	66%	279.41***	30.316
Yes, I do use	641	34%	255.64***	30.193

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	764	60%	262.93***	39.608
At least once a month or more	504	40%	249.49***	38.536
Time per day spent on computer				
None	591	47%	264.79***	41.411
Half an hour or more	670	53%	251.39***	37.327
Use calculator computer program for math class				
No, I do not use	632	52%	265.41	38.319
Yes, I do use	578	48%	252.26	39.153
Didactic: Use computer program to drill on math facts				
No, I do not use	584	47%	272.17***	38.212
Yes, I do use	649	53%	246.21***	36.634
Constructivist: Use spreadsheet program for math assignments				
No, I do not use	725	59%	267.66***	37.871
Yes, I do use	508	41%	245.14***	38.437
Constructivist: Use computer program for new lessons on problem solving				
No, I do not use	576	47%	272.15***	39.074
Yes, I do use	645	53%	247.00***	35.867
Constructivist: Use internet to learn things for math class				
No, I do not use	601	49%	269.54***	38.594
Yes, I do use	624	51%	248.22***	37.570
Constructivist: Use graphing program for charts for math class				
No, I do not use	691	57%	265.55***	37.153
Yes, I do use	521	43%	250.23***	40.763
Constructivist: Use statistical computer program for math class				
No, I do not use	797	66%	269.92***	37.320
Yes, I do use	414	34%	238.13***	34.653
Constructivist: Use word computer processing program for math class				

No, I do not use	701	58%	266.73***	35.178
Yes, I do use	508	42%	248.42***	42.595

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	795	69%	285.56***	36.259
At least once a month or more	351	31%	265.44***	32.681
Time per day spent on computer				
None	540	47%	285.67***	36.608
Half an hour or more	598	53%	273.88***	34.820
Use calculator computer program for math class				
No, I do not use	665	61%	285.01	34.709
Yes, I do use	417	39%	274.82	36.273
Didactic: Use computer program to drill on math facts				
No, I do not use	661	60%	289.51***	34.235
Yes, I do use	437	40%	267.20***	33.896
Constructivist: Use spreadsheet program for math assignments				
No, I do not use	810	74%	286.93***	34.883
Yes, I do use	290	26%	262.87***	32.093
Constructivist: Use computer program for new lessons on problem solving				
No, I do not use	654	60%	289.99***	34.483
Yes, I do use	436	40%	266.73***	33.227
Constructivist: Use internet to learn things for math class				
No, I do not use	634	58%	287.90***	34.014
Yes, I do use	453	42%	270.78***	36.042
Constructivist: Use graphing program for charts for math class				
No, I do not use	814	75%	287.12***	34.430
Yes, I do use	267	25%	260.98***	33.065
Constructivist: Use statistical computer program for math class				
No, I do not use	862	80%	286.91***	33.864
Yes, I do use	215	20%	256.17***	33.298
Constructivist: Use word computer processing program for math class				
No, I do not use	782	73%	286.71***	33.603
Yes, I do use	296	27%	265.18***	36.976

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Use computer at school for math				
Never or hardly ever	1,518	61%	275.18***	32.626
At least once a month or more	982	39%	267.52***	33.413
Time per day spent on computer				
None	933	37%	276.05***	34.746
Half an hour or more	1,567	63%	269.70***	32.037
Use calculator computer program for math class				
No, I do not use	1,194	49%	279.32***	31.982
Yes, I do use	1,221	51%	266.65***	32.410
Didactic: Use computer program to drill on math facts				
No, I do not use	1,205	49%	281.91***	31.277
Yes, I do use	1,244	51%	263.92***	31.702
Constructivist: Use spreadsheet program for math assignments				
No, I do not use	1,587	65%	280.07***	31.251
Yes, I do use	863	35%	259.30***	31.374
Constructivist: Use computer program for new lessons on problem solving				
No, I do not use	1,050	43%	281.90***	31.170
Yes, I do use	1,385	57%	265.69***	32.411
Constructivist: Use internet to learn things for math class				
No, I do not use	1,160	48%	279.61***	31.629
Yes, I do use	1,266	52%	266.71***	32.600
Constructivist: Use graphing program for charts for math class				
No, I do not use	1,597	66%	278.87***	30.842
Yes, I do use	811	34%	260.95***	33.324
Constructivist: Use statistical computer program for math class				
No, I do not use	1,798	75%	279.80***	30.190
Yes, I do use	606	25%	252.40***	31.696
Constructivist: Use word computer processing program for math class				
No, I do not use	1,702	71%	279.93***	30.125
Yes, I do use	702	29%	255.40***	32.761

* $p < .05$; ** $p < .01$; *** $p < .001$

Teacher Computer Usage Grade Four: Data revealed that the most commonly reported technology strategies used for grade four were two didactic approaches “practice/review math” and “play math games” and one constructivist approach “extend math learning”. For example, more than 70 percent of all teachers in LCs, Chicago, D.C. and Miami - with the exception of Boston (42 percent) - responded that students use computers for these three purposes. While the other two constructivist approaches “students use computer to research a math topic” and “students use computer to draw geometric shapes” were less likely to be used in the classroom. These characteristics of mathematics teachers may provide insight into the types of computer applications that are most commonly used in urban school classrooms.

Independent t-test analysis revealed that all of the technology approaches reported by grade four teachers had a significant and negative relationship with student math scores for LCs and TUDAs. Particularly, the two didactic approaches (i.e. practice/review math and play math games) had the largest negative effects on student standardized scores. As presented in Table 24, students who use computers to practice/review math more than once a month had statistically significant lower scores in Miami ($M=234.71$, $SD=26.762$) compared to those who did not ($M=244.39$, $SD=20.087$) conditions; $t(2,191)$ 3.483, $p<0.01$. A similar negative relationship was present in Chicago and D.C. Additionally, teachers in Miami who reported using computers to “play math games” more than once a month had students with lower test scores ($M=234.26$, $SD=26.441$), compared to those who did not use the approach ($M=241.62$, $SD=27.160$) conditions; $t(2,184)$ 4.184, p<0.001. While these two approaches were the most commonly used in LC and TUDA classrooms, they appear to have negative effects on student learning. These results potentially indicate that while didactic program applications are being administered in grade four math classrooms, they are hindering learning and decreasing student achievement on standardized exams for most urban areas.

Table 23: Summary of Teacher Reported Classroom Usage: Grade Four Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Availability of computers for teacher/students	+	+	Not Significant	Not Significant	-	+
Didactic: Students use computer to practice/review math	+	+	-	-	Not Significant	-
Didactic: Students use computer to play math games	+	+	Not Significant	-	Not Significant	-
Constructivist: Students use computer to extend math learning	-	-	-	-	Not Significant	+
Constructivist: Students use computer to research a math topic	-	+	Not Significant	-	+	+
Constructivist: Students use computer to draw geometric shapes	-	Not Significant	-	-	Not Significant	Not Significant

Table 24: Teacher Reported Classroom Usage: Grade Four Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Availability of computers for teacher/students				
No, availability	466	1%	230.62***	31.336
Yes, availability	45,029	99%	232.04***	28.949
Didactic: Students use computer to practice/review math				
Never or hardly ever	10,925	24%	231.50**	29.832
At least once a month or more	34,563	76%	232.12**	28.669
Didactic: Students use computer to play math games				
Never or hardly ever	9,361	21%	231.70**	29.617
At least once a month or more	36,156	79%	232.06**	28.780
Constructivist: Students use computer to extend math learning				
Never or hardly ever	12,902	28%	231.98***	29.220
At least once a month or more	32,599	72%	232.01***	28.838
Constructivist: Students use computer to research a math topic				
Never or hardly ever	31,055	68%	231.95***	29.002
At least once a month or more	14,373	32%	232.13***	28.845
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	34,301	76%	232.10***	28.995
At least once a month or more	11,071	24%	231.67***	28.803

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Availability of computers for teacher/students				
No, availability	33	2%	226.65	27.054
Yes, availability	2,075	98%	224.19	28.511
Didactic: Students use computer to practice/review math				
Never or hardly ever	672	32%	227.22***	28.461
At least once a month or more	1,429	68%	221.93***	27.968
Didactic: Students use computer to play math games				
Never or hardly ever	646	31%	223.73	29.583
At least once a month or more	1,458	69%	223.94	27.949
Constructivist: Students use computer to extend math learning				
Never or hardly ever	554	26%	227.15***	29.677
At least once a month or more	1,566	74%	222.84***	27.844
Constructivist: Students use computer to research a math topic				

Never or hardly ever	696	33%	224.07	28.658
At least once a month or more	1,423	67%	223.98	28.171
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	1,596	75%	224.63*	28.819
At least once a month or more	525	25%	221.83*	27.034

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Availability of computers for teacher/students				
No, availability	39	3%	217.99	36.005
Yes, availability	1,086	97%	222.20	36.066
Didactic: Students use computer to practice/review math				
Never or hardly ever	663	59%	226.78***	36.508
At least once a month or more	452	41%	214.71***	34.210
Didactic: Students use computer to play math games				
Never or hardly ever	354	32%	232.06***	39.304
At least once a month or more	758	68%	217.17***	33.479
Constructivist: Students use computer to extend math learning				
Never or hardly ever	319	29%	226.88**	38.411
At least once a month or more	793	71%	219.91**	34.944
Constructivist: Students use computer to research a math topic				
Never or hardly ever	747	67%	226.17***	36.963
At least once a month or more	365	33%	213.19***	32.598
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	878	80%	225.56***	36.718
At least once a month or more	225	20%	208.47***	29.429

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Availability of computers for teacher/students				
No, availability	93	6%	249.97***	31.621
Yes, availability	1,501	94%	236.94***	25.169
Didactic: Students use computer to practice/review math				
Never or hardly ever	816	51%	238.28	27.184
At least once a month or more	771	49%	237.06	24.218
Didactic: Students use computer to play math games				
Never or hardly ever	606	38%	238.77	26.965

At least once a month or more	988	62%	237.04	24.984
Constructivist: Students use computer to extend math learning				
Never or hardly ever	922	58%	238.54	26.596
At least once a month or more	672	42%	236.54	24.540
Constructivist: Students use computer to research a math topic				
Never or hardly ever	1,326	84%	236.55***	25.795
At least once a month or more	261	16%	243.48***	24.986
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	1,285	81%	237.56	25.797
At least once a month or more	306	19%	238.53	25.613

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Availability of computers for teacher/students				
No, availability	312	12%	229.14***	23.281
Yes, availability	2,193	88%	235.12***	26.587
Didactic: Students use computer to practice/review math				
Never or hardly ever	95	4%	244.39***	20.087
At least once a month or more	2,098	96%	234.71***	26.762
Didactic: Students use computer to play math games				
Never or hardly ever	258	12%	241.62***	27.160
At least once a month or more	1,928	88%	234.26***	26.441
Constructivist: Students use computer to extend math learning				
Never or hardly ever	168	8%	233.16	22.940
At least once a month or more	2,038	92%	235.35	26.806
Constructivist: Students use computer to research a math topic				
Never or hardly ever	1,318	60%	233.89**	25.922
At least once a month or more	875	40%	237.00**	27.445
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	1,368	63%	235.93	26.886
At least once a month or more	817	37%	233.76	26.114

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

Teacher Computer Usage Grade Eight: As presented in Table 26, an investigation of the frequency of use among grade eight math teachers in LCs and in TUDAs found that over half reported using didactic approaches to "practice or review math" or to "play math games," with the exception of Boston which reported 36 percent and 35 percent respectively. In LCs and TUDAs, teachers were less likely to report using constructivist approaches such as to "research a math topic," "draw geometric shapes," "graphing programs," or "email about math."

Furthermore, grade eight independent t-test analysis indicated that while didactic approaches were more commonly used in LC and TUDA classrooms, those students who used these applications had lower test scores. For example, teachers in Boston who reported using the computer for their students to "practice or review math" had significantly lower scores (M=268.89, SD=31.637) compared to those students who did not (M=287.68, SD=37.796) conditions; t(989) 7.969, p<0.001. Teachers in LCs, Chicago, Boston and Miami who reported using the other didactic approach to "play math games" had students with lower test scores. This may suggest that grade eight teachers in urban middle school teachers are filling the class time with using computers for didactic programs (i.e. drill and practice) that are not productively assisting students in developing math concepts, and are proving to be negatively related to student performance.

In all TUDA regions, grade eight teachers were more likely to use didactic approaches compared to constructivist. Despite the limited constructivist programs in classrooms, an independent t-tests indicate that these applications may be related to increased student achievement. The three constructivist applications found to increase test scores when used more than once a month are: drawing geometric shapes, graphing programs, and emailing about math. Table 25 summarizes the associations between didactic and constructivist software applications, and the mean scores of students.

Table 25: Summary of Teacher Reported Classroom Usage: Grade Eight Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Students use computer for four function calculator	-	-	Not Significant	Not Significant	-	-
Student use computer use scientific calculator	+	+	Not Significant	-	+	+
Students use computer use graphing calculator	+	+	+	Not Significant	+	+
Didactic: Students use computer practice or review math	-	-	Not Significant	Not Significant	-	Not Significant
Didactic: Students use computer to play math games	-	-	-	+	-	-
Constructivist: Students use computer extend math learning	-	-	-	-	-	-
Constructivist: Students use computer research a math topic	-	-	-	+	Not Significant	Not Significant
Constructivist: Students use computer to draw geometric shapes	+	+	-	+	Not Significant	Not Significant
Constructivist: Students use computer use for graphing program	+	+	+	+	Not Significant	+
Constructivist: Students use computer email about math	+	+	+	+	+	+

Table 26: Teacher Reported Classroom Usage: Grade Eight Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Students use computer for four function calculator				
Never or hardly ever	17,731	50%	274.20***	35.948
At least once a month or more	18,030	50%	270.42***	36.103
Student use computer use scientific calculator				
Never or hardly ever	19,570	55%	271.20***	36.181
At least once a month or more	16,208	45%	273.70***	35.966
Students use computer use graphing calculator				
Never or hardly ever	20,266	57%	267.60***	35.199
At least once a month or more	15,556	43%	278.54***	36.248
Didactic: Students use computer practice or review math				
Never or hardly ever	16,305	45%	273.72***	35.954
At least once a month or more	19,583	55%	271.18***	36.149
Didactic: Students use computer to play math games				
Never or hardly ever	18,730	52%	275.61***	36.227
At least once a month or more	17,120	48%	268.81***	35.574
Constructivist: Students use computer extend math learning				
Never or hardly ever	17,709	49%	273.85***	35.899
At least once a month or more	18,115	51%	270.88***	36.193
Constructivist: Students use computer research a math topic				
Never or hardly ever	26,862	75%	272.46***	36.014
At least once a month or more	8,994	25%	272.03***	36.235
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	30,776	86%	272.05***	35.658
At least once a month or more	5,003	14%	274.05***	38.595
Constructivist: Students use computer use for graphing program				
Never or hardly ever	26,997	76%	270.64***	35.742
At least once a month or more	8,757	24%	277.68***	36.600
Constructivist: Students use computer email about math				
Never or hardly ever	25,588	71%	268.80***	35.301
At least once a month or more	10,231	29%	281.37***	36.418

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Students use computer for four function calculator				

Never or hardly ever	697	44%	270.35	30.947
At least once a month or more	877	56%	272.56	32.383
Student use computer use scientific calculator				
Never or hardly ever	271	17%	270.70	30.759
At least once a month or more	1,303	83%	271.77	31.978
Students use computer use graphing calculator				
Never or hardly ever	912	59%	264.97***	29.406
At least once a month or more	646	41%	281.36***	32.577
Didactic: Students use computer practice or review math				
Never or hardly ever	709	45%	273.15	32.613
At least once a month or more	865	55%	270.30	31.011
Didactic: Students use computer to play math games				
Never or hardly ever	726	47%	274.59***	32.062
At least once a month or more	832	53%	269.29***	31.368
Constructivist: Students use computer extend math learning				
Never or hardly ever	827	53%	273.26***	32.306
At least once a month or more	747	47%	269.72***	31.069
Constructivist: Students use computer research a math topic				
Never or hardly ever	1,193	76%	272.73*	32.250
At least once a month or more	381	24%	268.00*	29.951
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	1,338	86%	272.26***	32.079
At least once a month or more	220	14%	268.76***	29.888
Constructivist: Students use computer use for graphing program				
Never or hardly ever	1,158	74%	269.27***	31.151
At least once a month or more	400	26%	278.97***	32.566
Constructivist: Students use computer email about math				
Never or hardly ever	1,004	65%	271.29***	31.395
At least once a month or more	545	35%	272.63***	32.633

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Students use computer for four function calculator				
Never or hardly ever	671	59%	257.60	39.400
At least once a month or more	466	41%	260.83	41.042
Student use computer use scientific calculator				
Never or hardly ever	791	69%	260.36*	38.186

At least once a month or more	352	31%	254.47*	44.588
Students use computer use graphing calculator				
Never or hardly ever	713	63%	258.45	40.741
At least once a month or more	423	37%	259.78	39.045
Didactic: Students use computer practice or review math				
Never or hardly ever	504	44%	259.13	38.136
At least once a month or more	633	56%	258.76	41.618
Didactic: Students use computer to play math games				
Never or hardly ever	397	35%	255.80*	35.206
At least once a month or more	739	65%	260.66*	42.416
Constructivist: Students use computer extend math learning				
Never or hardly ever	488	43%	260.71***	38.718
At least once a month or more	649	57%	257.58***	41.078
Constructivist: Students use computer research a math topic				
Never or hardly ever	857	75%	257.47*	39.624
At least once a month or more	280	25%	263.39*	41.256
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	891	78%	256.92***	39.073
At least once a month or more	246	22%	266.18***	42.901
Constructivist: Students use computer use for graphing program				
Never or hardly ever	862	76%	251.06***	35.300
At least once a month or more	275	24%	283.58***	44.097
Constructivist: Students use computer email about math				
Never or hardly ever	862	76%	251.06***	35.300
At least once a month or more	275	24%	283.58***	44.097

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Students use computer for four function calculator				
Never or hardly ever	420	42%	286.50***	35.627
At least once a month or more	569	58%	276.81***	37.127
Student use computer use scientific calculator				
Never or hardly ever	572	58%	271.74***	32.886
At least once a month or more	419	42%	293.30***	38.208
Students use computer use graphing calculator				
Never or hardly ever	355	36%	268.76***	34.964
At least once a month or more	636	64%	287.61***	36.076

Didactic: Students use computer practice or review math				
Never or hardly ever	631	64%	287.68***	37.796
At least once a month or more	360	36%	268.89***	31.637
Didactic: Students use computer to play math games				
Never or hardly ever	649	65%	287.37***	37.574
At least once a month or more	342	35%	268.49***	31.831
Constructivist: Students use computer extend math learning				
Never or hardly ever	597	60%	283.92***	36.090
At least once a month or more	394	40%	276.21***	37.401
Constructivist: Students use computer research a math topic				
Never or hardly ever	743	75%	280.00	36.288
At least once a month or more	248	25%	283.40	38.228
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	887	90%	281.56	36.756
At least once a month or more	104	10%	274.82	36.726
Constructivist: Students use computer use for graphing program				
Never or hardly ever	735	74%	281.56	37.869
At least once a month or more	256	26%	278.83	33.497
Constructivist: Students use computer email about math				
Never or hardly ever	583	59%	274.17***	33.253
At least once a month or more	408	41%	290.41***	39.445

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Students use computer for four function calculator				
Never or hardly ever	282	13%	278.92***	38.183
At least once a month or more	1,895	87%	270.49***	33.101
Student use computer use scientific calculator				
Never or hardly ever	1,305	60%	265.38***	32.853
At least once a month or more	876	40%	280.47***	33.415
Students use computer use graphing calculator				
Never or hardly ever	1,903	87%	269.80***	33.869
At least once a month or more	290	13%	283.03***	31.423
Didactic: Students use computer practice or review math				
Never or hardly ever	399	18%	271.51	33.679
At least once a month or more	1,791	82%	271.52	33.910
Didactic: Students use computer to play math games				

Never or hardly ever	1,101	50%	275.93***	33.892
At least once a month or more	1,089	50%	267.05***	33.253
Constructivist: Students use computer extend math learning				
Never or hardly ever	506	23%	274.70**	35.883
At least once a month or more	1,675	77%	270.57**	33.147
Constructivist: Students use computer research a math topic				
Never or hardly ever	1,219	56%	270.99	33.784
At least once a month or more	960	44%	272.58	33.950
Constructivist: Students use computer to draw geometric shapes				
Never or hardly ever	1,776	81%	271.80	33.879
At least once a month or more	412	19%	271.02	33.515
Constructivist: Students use computer use for graphing program				
Never or hardly ever	1,664	76%	270.65**	33.965
At least once a month or more	516	24%	275.07**	33.193
Constructivist: Students use computer email about math				
Never or hardly ever	1,557	71%	266.97***	32.538
At least once a month or more	631	29%	283.22***	34.113

* $p < .05$; ** $p < .01$; *** $p < .001$

Teacher Computer Competency Grade Four: Table 28 presents the responses of grade four teachers in LCs and TUDAs when asked about their exposure to training in technology within the last five years. Less than a third of teachers reported receiving professional development for the use of computers or other technology at their schools - Large Cities (39 percent), Chicago (32 percent), D.C. (25 percent), Boston (16 percent) while Miami had reported more professional development (62 percent). Despite the lack of professional development offered at the schools, a majority of teachers reported receiving training or were already proficient in basic computers, software applications, other technologies and integrating technology into instruction.

The dichotomous nature of these variables prevents a thorough analysis of the quantity of training received by these teachers. However, the high percentage of teachers reporting that they were already proficient or had received training may serve as an indication that few teachers felt that they lacked the knowledge or ability to use basic computers, software applications or to properly integrate technology into the classroom. Furthermore, as illustrated in Table 28, training in basic computers, software applications, use of internet, use of other technology and integrating computers into instruction have had a positive significant impact on student test scores in LC's and in most TUDA's, while teachers' exposure to professional development on the use of technology appears to have a negative impact on student scores. For example, teachers who reported having little or no professional development in computers had higher test scores ($M=226$, $SD=36.939$) compared to those who reported having moderate or large extent ($M=209.56$, $SD=30.777$) conditions; $t(1,169)$ 6.899; $p<0.001$. This might suggest that overall professional development for computers might need to be focused on content specific courses rather than a broad perspective on how to integrate computers into the classroom.

Table 27: Summary of Teacher Computer Competency: Grade Four Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Prof dev-use of computers or other technology	-	-	-	-	Not Significant	Not Significant
Training in basic computers	+	+	Not Significant	-	+	Not Significant
Training in software applications	+	+	+	Not Significant	+	+
Training in use of the Internet	+	+	Not Significant	Not Significant	-	+
Training in use of other technology	+	+	+	Not Significant	Not Significant	Not Significant
Training in integrating computers into instruction	+	+	Not Significant	Not Significant	Not Significant	+

Table 28: Teacher Computer Competency: Grade Four Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	28,928	61%	232.16***	29.361
Moderate to Large extent	18,188	39%	231.31***	28.223
Training in basic computers				
No, I have not received training	6,405	14%	229.57***	29.213
Yes, I have received training or I am already proficient	40,826	86%	232.20***	28.887
Training in software applications				
No, I have not received training	13,893	30%	229.72***	28.786
Yes, I have received training or I am already proficient	33,199	70%	232.73***	28.988
Training in use of the Internet				
No, I have not received training	6,787	14%	230.97**	29.319

Yes, I have received training or I am already proficient	40,097	86%	232.06**	28.903
Training in use of other technology				
No, I have not received training	20,771	44%	230.26***	29.012
Yes, I have received training or I am already proficient	26,329	56%	233.14***	28.838
Training in integrating computers into instruction				
No, I have not received training	9,093	19%	229.16***	29.412
Yes, I have received training or I am already proficient	38,035	81%	232.46***	28.811

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	1,484	68%	225.11***	28.222
Moderate to Large extent	700	32%	221.63***	28.508
Training in basic computers				
No, I have not received training	261	12%	222.83	29.293
Yes, I have received training or I am already proficient	1,928	88%	224.00	28.365
Training in software applications				
No, I have not received training	515	24%	219.16***	27.666
Yes, I have received training or I am already proficient	1,651	76%	225.32***	28.635
Training in use of the Internet				
No, I have not received training	261	12%	221.52	28.241
Yes, I have received training or I am already proficient	1,910	88%	224.11	28.490
Training in use of other technology				
No, I have not received training	981	45%	222.26**	28.406
Yes, I have received training or I am already proficient	1,197	55%	225.10**	28.537
Training in integrating computers into instruction				

No, I have not received training	515	24%	222.07	28.680
Yes, I have received training or I am already proficient	1,661	76%	224.26	28.374

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	874	75%	226.00***	36.939
Moderate to Large extent	297	25%	209.56***	30.777
Training in basic computers				
No, I have not received training	294	25%	227.15**	38.003
Yes, I have received training or I am already proficient	889	75%	219.76**	35.381
Training in software applications				
No, I have not received training	469	40%	221.57	37.147
Yes, I have received training or I am already proficient	715	60%	221.63	35.529
Training in use of the Internet				
No, I have not received training	203	17%	222.84	40.862
Yes, I have received training or I am already proficient	965	83%	221.42	35.303
Training in use of other technology				
No, I have not received training	584	50%	220.54	38.329
Yes, I have received training or I am already proficient	591	50%	222.36	33.893
Training in integrating computers into instruction				
No, I have not received training	348	30%	223.09	38.035
Yes, I have received training or I am already proficient	823	70%	220.97	35.440

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				

Not at all or very small extent	1,370	84%	237.73	25.723
Moderate to Large extent	261	16%	236.74	25.465
Training in basic computers				
No, I have not received training	268	17%	234.20**	25.333
Yes, I have received training or I am already proficient	1,353	83%	238.33**	25.685
Training in software applications				
No, I have not received training	699	44%	236.08*	25.137
Yes, I have received training or I am already proficient	902	56%	238.90*	26.102
Training in use of the Internet				
No, I have not received training	289	18%	237.89**	25.101
Yes, I have received training or I am already proficient	1,320	82%	237.78**	25.744
Training in use of other technology				
No, I have not received training	982	61%	237.37	25.301
Yes, I have received training or I am already proficient	624	39%	238.12	26.435
Training in integrating computers into instruction				
No, I have not received training	749	47%	237.84	25.569
Yes, I have received training or I am already proficient	853	53%	237.51	25.974

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	912	38%	235.46	28.073
Moderate to Large extent	1,511	62%	234.38	25.585
Training in basic computers				
No, I have not received training	362	15%	234.66	28.317
Yes, I have received training or I am already proficient	2,080	85%	234.77	26.321
Training in software applications				

No, I have not received training	695	28%	232.46*	25.809
Yes, I have received training or I am already proficient	1,757	72%	235.55*	26.959
Training in use of the Internet				
No, I have not received training	476	19%	234.17**	27.351
Yes, I have received training or I am already proficient	1,969	81%	234.87**	26.473
Training in use of other technology				
No, I have not received training	1,255	51%	234.46	27.718
Yes, I have received training or I am already proficient	1,194	49%	235.02	25.450
Training in integrating computers into instruction				
No, I have not received training	449	18%	228.60**	26.572
Yes, I have received training or I am already proficient	1,994	82%	236.04**	26.543

* $p < .05$; ** $p < .01$; *** $p < .001$

Teacher Computer Competency Grade Eight: Teachers only responded to one question about teacher computer competency. As illustrated in Table 30 over 80 percent of all teachers' were exposed to professional development, with the exception of D.C. (64 percent). Teachers in LC's and Chicago with moderate to a large extent of professional development had improved student scores, while Boston teachers student scores decreased.

Table 29: Summary of Teacher Computer Competency: Grade Eight Large City and TUDAs

Indicator	National	Large City	Chicago	D.C.	Boston	Miami
Prof dev-use of computers or other technology	+	+	+	Not Significant	-	Not Significant

Table 30: Teacher Computer Competency: Grade Eight Large City and TUDAs

Large City

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	6,113	17%	271.47*	35.918
Moderate to Large extent	29,961	83%	272.49*	36.021

Chicago

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	275	17%	267.76*	25.921
Moderate to Large extent	1,307	83%	272.57*	32.606

D.C.

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	389	36%	261.05	40.787
Moderate to Large extent	681	64%	258.88	40.619

Boston

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	199	20%	284.99*	37.188
Moderate to Large extent	801	80%	278.97*	36.223

Miami

NAEP Variables	N	Frequency	Mean Score	Std Dev
Prof dev-use of computers or other technology				
Not at all or very small extent	187	9%	272.17	34.015
Moderate to Large extent	2,009	91%	271.90	33.780

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

Phase 3: Ordinary Least Squares Regression

This study investigates the relationship between home and classroom access as well as student and teacher usage to student achievement. Also of interest is the relationship between teachers' professional development in technology and computer competency relative student achievement. To address these focus areas, differences in students' standardized math scores were assessed using OLS procedures. This method was useful for the context of this data since students exist within a hierarchical social structure which includes demographics, the family structure, the home, classroom, grade level, and geographic regions. Employing OLS assists in identifying the relationship that exists between the predictors and the outcome and to manage unbalanced data as each region had different sample sizes of students.

The regression analysis has two subsections to assess the national and Large City/ TUDA separately. The first section addresses the impact of Models 1 to 7 at the national level for grade four and grade eight. The second section investigates the impact of Model 7 in Large Cities, Chicago, D.C., Boston, and Miami for grade four and grade eight.

National Regression Models.

The national analysis evaluates the impact of Models 1 to 7 for grade four and grade eight separately. The first model (Model 1) evaluated if there was sufficient variability between the predictor demographic variables: gender, race, free or reduced lunch eligibility, and parent educational level; and the composite math scores. Results of the analysis for grade four indicate that 22.7 percent of the variability in students' standardized math scores are attributed to demographic predictors while in grade eight these variables accounted for 24 percent of the variance in students' scores. The OLS regression for models 2 to 7 are different for grade four and grade eight since the predictor variables are not the same for access, usage, and teacher computer competency, thus they are assessed separately.

The first model of the OLS regression equation (i.e. Model 1) for grade four is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status)

Model 2 for grade four addresses the first research question with the inclusion of computers in the home (B017101), while controlling for the demographic variables. This model would be represented as:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (B017101)

Model 3 adds the next level of predictors to address school access and incorporates: percent of classrooms with computer (C071507), percent classrooms with computer printer (C071508), percent classrooms with Internet (C071509), and percent classrooms with handheld devices (C071511). The equation for Model 3 is:

> Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (B017101) + b5 (C071507) + b6 (C071508) + b7 (C071509) + b8 (C071511)

Next, Model 4 addresses student home usage and adds to the model: using the internet at home (M820401) and using the computer at home for math homework (M823901). The equation for Model 4 is:

> Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (B017101) + b5 (C071507) + b6 (C071508) + b7 (C071509) + b8 (C071511) + b9 (M820401) + b10 (M823901)

Model 5 incorporates student classroom usage predictors: use the computer at school for math (M814301), use computer to practice or drill on math (M814601), use computer to play math games (M814701), to make charts or graphs for math (M814501), and to use the internet to learn things about math (M814901). The equation for Model 5 is:

> Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (B017101) + b5 (C071507) + b6 (C071508) + b7 (C071509) + b8 (C071511) + b9 (M820401) + b10 (M823901) + b11 (M814301) + b12 (M814601) + b13 (M814701) + b14 (M814501) + b15 (M814901)

Model 6 addresses the research question on teacher computer usage and adds to the equation the following predictors: availability of computers (T088301), using four function calculator (T106610), to practice/review math (T106601), play math games (T106609), extend math learning (T106602), research a math topic (T106603), and draw geometric shapes (T106606). The equation for Model 6 is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (B017101) + b5 (C071507) + b6 (C071508) + b7 (C071509) + b8 (C071511) + b9 (M820401) + b10 (M823901) + b11 (M814301) + b12 (M814601) + b13 (M814701) + b14 (M814501) + b15 (M814901) + b16 (T088301) + b17 (T106610) + b18 (T106601) + b19 (T106609) + b20 (T106602) +b21 (T106603) + b22 (T106606)

The full model (Model 7) addresses all six research questions with the inclusion of teacher computer competency predictors: professional development use (T087708), training in basic computers (T097501), software applications (T097502), use of the Internet (T097503), use of technology (T097504), and integrating computers into instruction (T097505). The equation for Model 7 is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (B017101) + b5 (C071507) + b6 (C071508) + b7 (C071509) + b8 (C071511) + b9 (M820401) + b10 (M823901) + b11 (M814301) + b12 (M814601) + b13 (M814701) + b14 (M814501) + b15 (M814901) + b16 (T088301) + b17 (T106610) + b18 (T106601) + b19 (T106609) + b20 (T106602) +b21 (T106603) + b22 (T106606) + b23 (T087708) + b24 (T097501) + b25 (T097502) +b26 (T097503) + b27 (T097504) + b28 (T097505)

Analysis of the weighted and non-imputed data using a non-randomly varying slopes model revealed several significant predictors as illustrated in Table 31. Model 1 predictors accounted for 22.7 percent of the variability in students' standardized mathematics scores at the national level. Model 2 included computer access in the home and accounted for 23.2 percent, followed by school access at 23.2 percent, student computer home usage 24.9 percent, student computer classroom usage 26.9 percent, teacher classroom usage 26.1 percent and the final model teacher computer competency at 26.2 percent. Therefore, Model 7 used all predictors, and was found to be a good fit (adjusted R2

= 0.262), and the overall relationship was significant $F(31, 151{,}615) = 1{,}737.52$, $p<0.001$. Table 31 displays the regression results that describe the overall relationship between technology access, usage and teacher computer competency and math standardized achievement.

Table 31: Grade Four National Summary of Plausible Value OLS Model for Variables Predicting Math Achievement

NAEP Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Gender							
	-1.250***	-1.304***	-1.303***	-1.085***	-1.334***	-1.320***	-1.328***
Race							
Black	-17.887***	-17.802***	-17.759***	-17.531***	-16.845***	-17.014***	-16.992***
Hispanic	-10.718***	-10.412***	-10.389***	-9.902***	-9.508***	-9.436***	-9.398***
Asian	4.213***	4.058***	4.112***	4.006***	4.477**	4.564***	4.603***
Other	-8.928***	-8.526***	-8.504***	-8.056***	-7.879***	-7.855***	-7.809***
National School Lunch Program							
	-16.969***	-16.253***	-16.217***	-15.562***	-15.051***	-15.051***	-14.987***
Computer in the Home							
	-	6.393***	6.384***	1.868***	1.638***	1.669***	1.676***
School Access							
Percent classrooms with computer	-	-	2.131***	2.235***	2.348***	1.994***	1.957***
Percent classrooms with computer printer	-	-	-.446***	-.505***	-.607***	-.477***	-.623***
Percent classrooms with Internet	-	-	-1.046***	-1.059***	-.998***	-1.039***	-1.063***
Percent classrooms with handheld devices	-	-	-.027***	.009***	.062***	-.054***	-.162***
Student Computer Usage: Home							
Use the internet at home	-	-	-	8.463***	8.324***	8.338***	8.328***
Use the computer at home for math homework	-	-	-	-7.193***	-6.431***	-6.446***	-6.441***
Student Computer Usage: School							
Use computer at school for math	-	-	-	-	-2.402***	-2.593***	-2.618***
Didactic: Use computer to practice or drill on math	-	-	-	-	3.918***	3.872***	3.858***
Didactic: Use computer to play math games	-	-	-	-	-.656***	-.548	-.537***
Constructivist: Use computer to make charts or graphs for math	-	-	-	-	-5.631***	-5.658***	-5.664***

Constructivist: Use the internet to learn things about math	-	-	-	-	-1.619***	-1.647***	-1.647***
Teacher Computer Usage: School							
Availability of computers for teachers/students	-	-	-	-	-	2.526***	2.188***
Students use computer to use 4-function calculator	-	-	-	-	-	.677***	.609***
Didactic: Students use computer to practice/ review math	-	-	-	-	-	.404***	.227***
Didactic: Students use computer to play math games	-	-	-	-	-	.012***	-.087***
Constructivist Approach: Students use computer to extend math learning	-	-	-	-	-	.477***	.276***
Constructivist Approach: Students use computer to research math topic	-	-	-	-	-	1.434***	1.285***
Constructivist Approach: Students use computer to draw geometric shapes	-	-	-	-	-	-.082***	-.216***
Teacher Computer Competency							
Professional development use of computers or other technology	-	-	-	-	-	-	.137***
Training in Basic Computers	-	-	-	-	-	-	.802***
Training in software applications	-	-	-	-	-	-	.438***
Training in the use of internet	-	-	-	-	-	-	-.386***
Training in use of other technology	-	-	-	-	-	-	.711***
Training in integrating computers into instruction	-	-	-	-	-	-	1.262***
Constant							
	255.365	249.256	248.387	246.108	247.055	243.555	242.377
R Square							
	0.227	0.232	0.232	0.249	0.269	0.261	0.262
N							

	151,647	151,647	151,647	151,647	151,647	151,647	151,647

* $p < .05$; ** $p < .01$; *** $p < .001$

Model 1 for grade eight adds another component to the demographic predictors: parent educational level. The first model of the OLS regression equation (i.e. Model 1) for grade eight is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level)

Next, Model 2 addresses the first research question with the inclusion of computers in the home (B017101), while controlling for the demographic variables. The second model of the OLS regression equation for grade eight is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level) + b5 (B017101)

Model 3 adds the next level of predictors to address school access (T088301). The equation for Model 3 is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level) + b5 (B017101) + b6 (T088301)

Model 4 addresses student home usage by incorporating the following predictors: use the internet at home (M820401), computer at home for math homework (M823901), e-mail/message/blog to get math help (M820603) and e-mail/message/blog to get math help with friends (M821301). The equation for Model 4 is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level) + b5 (B017101) + b 6 (T088301) + b7 (M820401) + b8 (M823901) + b9 (M820603) + b10 (M821301)

Model 5 includes student classroom usage predictors: use the computer at school for math (M814301), time per day on computers (M815901), calculators (M816401), drill on math facts (M816101), spreadsheet programs (M816001), new lessons on problem solving (M816201), internet to learn things for math (M816301), graphing computer program (M816501), statistical computer program (M816601), and word computer processing program (M816701). The equation for Model 5 is:

> Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level) + b5 (B017101) + b 6 (T088301) + b7 (M820401) + b8 (M823901) + b9 (M820603) + b10 (M821301) + b11 (M814301) + b12 (M815901) + b13 (M816401) + b14 (M816101) + b15 (M816001) + b16 (M816201) + b17 (M816301) + b18 (M816501) + b19 (M816601) + b20 (M816701)

Model 6 adds teacher classroom usage and incorporates the following predictors: computer use four function calculator (T112610), scientific calculator (T112611), graphing calculator (T112612), practice or review math (T112601), play math games (T112609), extend math learning (T112602), research a math topic (T112603), draw geometric shapes (T112606), graphing programs (T112607) and email about math (T112608). The equation for Model 6 is:

> Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level) + b5 (B017101) + b 6 (T088301) + b7 (M820401) + b8 (M823901) + b9 (M820603) + b10 (M821301) + b11 (M814301) + b12 (M815901) + b13 (M816401) + b14 (M816101) + b15 (M816001) + b16 (M816201) + b17 (M816301) + b18 (M816501) + b19 (M816601) + b20 (M816701) + b21 (T112610) + b22 (T112611) + b23 (T112612) + b24 (T112601) + b25 (T112609) + b26 (T112602) + b27 (T112603) + b28 (T112606) + b29 (T112607) + b30 (T112608)

The full model addresses all six research questions with the inclusion of teacher computer competency predictors: professional development use (T087708). The equation for Model 7 is:

Y(test score) = Constant + b1 (gender) + b2 (race) + b3 (socio-economic-status) + b4 (parent education level) + b5 (B017101) + b 6 (T088301) + b7 (M820401) + b8 (M823901) + b9 (M820603) + b10 (M821301) + b11 (M814301) + b12 (M815901) + b13 (M816401) + b14 (M816101) + b15 (M816001) + b16 (M816201) + b17 (M816301) + b18 (M816501) + b19 (M816601) + b20 (M816701) + b21 (T112610) + b22 (T112611) + b23 (T112612) + b24 (T112601) + b25 (T112609) + b26 (T112602) + b27 (T112603) + b28 (T112606) + b29 (T112607) + b30 (T112608) + b31 (T087708)

Analysis of the weighted and non-imputed data using a non-randomly varying slopes model revealed several significant predictors as illustrated in Table 32. The demographic variables: gender, race, SES, and parent education levels in Model 1 accounted for 24.1 percent of the variance in students' standardized mathematics scores at the national level. While, Model 2 home access and Model 3 classroom access only accounted for an additional 0.3 percent (24.4 percent). Model 4 which included student computer home usage accounted for 27.3 percent of the variance, and Model 5 student computer classroom usage accounted for 34.2 percent of the variance -- a significant increase. Model 6 teacher classroom usage explained 35.7 percent of the variance and adding teacher computer competency did not effect the model. Model 7 included all of the predictors, and was found to be a good fit (adjusted R2 = 0.262), and the overall relationship was significant $F(35, 114{,}230) = 1{,}814.376$, $p<0.001$. Table 32 displays the regression results that describe the overall relationship between technology access, usage and teacher computer competency and math standardized achievement.

Table 32: Grade Eight: National Summary of Plausible Value OLS Model for Variables Predicting Math Achievement

NAEP Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Gender							
	-.051***	-.093***	-.797***	-.649***	-2.091***	-2.155***	-2.155***
Race							
Black	-23.549***	-23.376***	-21.912***	-20.645***	-17.162***	-17.369***	-17.368***
Hispanic	-10.015***	-9.918***	-8.903***	-7.991***	-6.612***	-6.534***	-6.531***
Asian	6.241***	6.117***	8.125***	8.460***	9.466***	9.210***	9.213***
Other	-11.179***	-10.765***	-9.956***	-9.395***	-8.292***	-7.820***	-7.817***
National School Lunch Program							
	-15.004***	-14.445***	-14.136***	-13.705***	-11.754***	-11.154***	-11.154***
Parent Education Level							
H.S. or less	-16.154***	-15.510***	-15.850***	-15.551***	-14.502***	-13.985***	-13.986***
Some College	-3.982***	-3.800***	-4.275***	-4.251***	-4.276***	-3.887***	-3.886***
Computer in the Home							
	-	8.659***	7.832***	4.137***	3.919***	3.843***	3.844***
School Access							
	-	-	1.371***	1.468***	2.170***	2.327***	2.306***
Student Computer Usage: Home							
Use the Internet at home	-	-	-	5.882***	4.754***	4.442***	4.439***
Use computer at home for math homework	-	-	-	-2.250***	2.375***	2.120***	2.120***
Use email/message/blog-get math help	-	-	-	-10.942***	-7.536***	-7.522***	-7.522***
Use email/message/blog-get math help with friends	-	-	-	5.405***	6.437***	6.185***	6.184***
Student Computer Usage: School							
Use computer at school for math	-	-	-	-	1.283***	1.582***	1.582***

Time per day spent on computer	-	-	-	-	-4.357***	-4.316***	-4.317***
Use calculator computer program for math class	-	-	-	-	1.347***	1.226***	1.226***
Didactic: Use computer program to drill on math facts	-	-	-	-	-6.756***	-6.359***	-6.359***
Constructivist: Use spreadsheet program for math assignments	-	-	-	-	-6.172***	-6.050***	-6.049***
Constructivist: Use computer program for new lessons on problem solving	-	-	-	-	-1.775***	-1.621***	-1.622***
Constructivist: Use internet to learn things for math class	-	-	-	-	.709***	.711***	.712***
Constructivist: Use graphing program for charts for math class	-	-	-	-	.660***	.074***	.072***
Constructivist: Use statistical computer program for math class	-	-	-	-	-9.802***	-9.759***	-9.760***
Constructivist: Use word computer processing program for math class	-	-	-	-	-5.373***	-5.333***	-5.331***
Teacher Computer Usage: School							
Students use computer for four function calculator	-	-	-	-	-	-2.626***	-2.626***
Student use computer use scientific calculator	-	-	-	-	-	1.681***	1.677***
Students use computer use graphing calculator	-	-	-	-	-	5.624***	5.615***
Didactic: Students use computer practice or review math	-	-	-	-	-	.957***	.941***
Didactic: Students use computer to play math games	-	-	-	-	-	-2.941***	-2.943***
Constructivist: Students use computer extend math learning	-	-	-	-	-	.469***	.452***
Constructivist: Students use computer research a math topic	-	-	-	-	-	-.645***	-.650***

Constructivist: Students use computer to draw geometric shapes	-	-	-	-	-	.105***	.099***
Constructivist: Students use computer use for graphing program	-	-	-	-	-	2.319***	2.314***
Constructivist: Students use computer email about math	-	-	-	-	-	3.491***	3.484***
Teacher Computer Competency							
Prof dev-use of computers or other technology	-	-	-	-	-	-	.225***
Constant							
	302.141	293.568	294.245	294.325	298.788	295.816	295.679
R Square							
	0.241	0.244	0.244	0.273	0.342	0.357	0.357
N							
	110,140	110,140	110,140	110,140	110,140	110,140	110,140

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

Large City and TUDA Regression Models.

In this section, I present the full model, Model 7, that addresses all six research questions on access, usage and teacher computer competency predictors for both grade four and grade eight. To examine the role of Model 7 in promoting academic performance of students, I separated the analysis by the regions of interest - LCs, Chicago, D.C., Boston, and Miami. However, before presenting the findings from Model 7, I discuss the impacts of demographics (Model 1) for LCs and TUDAs as it accounted for a large percentage of the variance in grade four and grade eight student achievement.

The demographic variables for grade four accounted for a large percentage of the variance in student achievement. Specifically, LC's demographic variables accounted for

23.4 percent of the variance, 17.5 percent of the variance in Chicago, 39.0 percent in DC, 19.7 percent in Boston and 15.2 percent in Miami. While these numbers illustrate the impact that gender, race and SES has on student achievement, Table 33, presents a detailed summary of the composite math scores for the expanded OLS regression Model 7. This model indicates a statistically significant effect for each of the regions of interest: LCs, Chicago, D.C., Boston and Miami. More specifically, LCs had approximately 28.2 percent of the total variance explained by Model 7 and was found to be a good fit, and the overall relationship was significant $F(31, 35{,}593) = 452.063$, $p<0.001$. Chicago had approximately 24.5 percent of the total variance explained by Model 7 and was found to be a good fit, and the overall relationship was significant $F(31, 1{,}541) = 17.462$, $p<0.001$. D.C. had approximately 44.7 percent of the total variance explained by Model 7 and was found to be a good fit, and the overall relationship was significant $F(31, 750) = 21.360$, $p<0.001$. Boston had approximately 28.3 percent of the total variance explained by Model 7 and was found to be a good fit, and the overall relationship was significant $F(31, 1{,}244) = 17.221$, $p<0.001$. Lastly, Miami had approximately 20.7 percent of the total variance explained and was found to be a good fit, and the overall relationship was significant $F(31, 1{,}692) = 15.955$, $p<0.001$. Below, Table 33 displays these regression results in more detail.

Table 33: Grade Four Large City and TUDA Summary of Plausible Value OLS Model 7 for Variables Predicting Math Achievement

NAEP Variables	Large City	Chicago	D.C.	Boston	Miami
Gender					
	-.188	1.671	6.028**	.628	-1.606
Race					
Black	-21.114***	-21.088***	-34.242***	-18.588***	-17.329***
Hispanic	-11.927***	-13.540***	-26.747***	-15.488***	-9.651***
Asian	1.007	6.332	2.537	4.040	8.856
Other	-7.264***	-.774	-5.387	-4.851	7.871
National School Lunch Program					
	-16.582***	-16.307***	-19.205***	-11.286***	-13.084***
Computer in the Home					
	1.452*	-2.011	-.869	1.040	.771
School Access					
Percent classrooms with computer	1.836***	-.182	-6.185	-4.491*	-6.365**
Percent classrooms with computer printer	-2.924	5.400	1.756	1.465	1.626
Percent classrooms with Internet	-.109***	1.370	5.560	-.653	4.858
Percent classrooms with handheld devices	1.031***	-.354	5.898**	-1.851	2.110
Student Computer Usage: Home					
Use the internet at home	8.999***	11.719***	11.862***	4.442*	9.918***
Use the computer at home for math homework	-7.290***	-8.748***	-7.803***	-4.195**	-4.529**
Student Computer Usage: School					
Use computer at school for math	-4.472***	-5.791***	-2.687	-6.834***	-5.651***
Didactic: Use computer to practice or drill on math	3.614***	1.800	2.774	7.169***	3.129*
Didactic: Use computer to play math games	-1.013***	.470	-1.746	-4.535**	1.766

Constructivist: Use computer to make charts or graphs for math	-6.583***	-7.614***	-6.328***	-9.420***	-4.547*
Constructivist: Use the internet to learn things about math	-1.141***	.428	-6.599***	-1.262	-.111
Teacher Computer Usage: School					
Availability of computers for teachers/students	-.636	10.255	-10.581	-13.120***	-.111
Students use computer to use 4-function calculator	.145	-.806	-2.975	-.462	1.951
Didactic: Students use computer to practice/ review math	1.467**	1.169	8.156	.992	-6.346*
Didactic: Students use computer to play math games	.739	.556	-11.353**	2.428	-5.911**
Constructivist Approach: Students use computer to extend math learning	.130	2.688	.582	-7.058**	3.378
Constructivist Approach: Students use computer to research math topic	2.104***	.785	9.481**	11.255***	3.354*
Constructivist Approach: Students use computer to draw geometric shapes	-.728*	-3.794*	-9.320**	.315	-.819
Teacher Computer Competency					
Professional development use of computers or other technology	.647*	-2.067	-12.201***	-1.953	-.550
Training in Basic Computers	.378	-7.640	-7.389*	3.422	.086
Training in software applications	1.339***	5.175**	-.873	3.957*	.747
Training in the use of internet	-.854	5.599	4.133	.062	-2.922
Training in use of other technology	.840**	.214	8.226**	-3.322	-1.837

Training in integrating computers into instruction	1.281**	3.378	7.402**	2.851	8.172*
Constant Model 1					
	259.353	258.049	271.382	262.011	261.364
Constant Model 7					
	249.455	228.887	266.029	267.672	255.665
R Square Model 1					
	0.234	0.175	0.390	0.197	0.152
R Square Model 7					
	0.282	0.260	0.469	0.300	0.221
N Model 1					
	35,625	1,573	782	1,276	1,723
N Model 7					
	35,625	1,573	782	1,276	1,723

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

Similar to grade four, the demographic variables for grade eight also accounted for a large percentage of the variance in student achievement. LC's demographic variables accounted for 25.4 percent of the variance, 23.5 percent of the variance in Chicago, 38.4 percent in DC, 27.3 percent in Boston and 20.5 percent in Miami. This illustrates that demographic variables: gender, race, SES, and parent educational level have a significant impact on student achievement across all regions.

To examine the role of -- access, usage and teacher computer competency for grade eight, Table 34 illustrates the OLS regression coefficient estimates for Model 7 by the regions of investigation: LC, Chicago, D.C., Boston and Miami. Overall, there were differences in effects of several predictor variables within the student home usage, student classroom usage and teacher classroom usage levels while home and school access as well as teacher computer competency showed no significant effects.

Across all LC and Chicago and D.C. school regions students who reported using the internet at home had a positive relationship with student achievement. Particularly, students in LCs, Chicago, D.C. and Miami who used email/message/blogs to get math help with friends had improved test scores. In the classroom environment, students in Large Cities, Chicago and Miami who reported using didactic approaches (i.e. drill and practice) had negative effects on student achievement. Teachers who reported using didactic approaches in the classroom had mixed results. Teachers in LC and Miami who reported using the computer to practice or review math had a positive impact on student scores, while teachers in Chicago and D.C. using this approach had a negative impact. In Large Cities, teachers who reported using the computer play math games (another didactic approach) had a negative effect on student scores. Furthermore, teachers who had students use the computer to email about math questions had a positive effect on student scores in LC, D.C., Boston and Miami. Finally, regression analysis revealed nonsignificant relationships between teacher computer competency and student math scores in all of the regions of investigation.

Table 34: Grade Eight: Large City and TUDA Summary of Plausible Value OLS Model 7 for Variables Predicting Math Achievement

NAEP Variables	Large City	Chicago	D.C.	Boston	Miami
Gender					
	-1.399***	.953	-1.691	-1.624	-3.965**
Race					
Black	-19.615***	-17.058***	-36.102***	-13.203***	-14.148***
Hispanic	-9.283***	-10.833***	-21.951***	-17.738***	.252
Asian	8.304***	9.839*	1.727	16.406***	17.559***
Other	-6.226***	-57.609**	-14.067**	-4.319	6.783
National School Lunch Program					
	-11.922***	-10.740***	-15.950***	-7.142**	-9.633***
Parent Education Level					
H.S. or less	-11.142***	-7.593***	-11.343***	-2.988	-12.341***
Some College	-1.290**	2.962	-.236	-1.802	-2.381
Computer in the Home					
	3.935***	.584	.143	10.123	.175
School Access					
	3.851**	18.595*	-5.789	-8.824	24.359
Student Computer Usage: Home					
Use the Internet at home	4.791***	6.323***	20.088***	9.710	7.503
Use computer at home for math homework	2.218***	3.731	.955	1.457	3.051*
Use email/message/blog-get math help	-8.048***	-6.482***	-10.388***	-7.667**	-8.728***
Student Computer Usage: School					
Use computer at school for math	.841*	5.603**	-.512	-.757	-.425
Time per day spent on computer	-2.980***	-3.465	-6.699**	-4.690*	-.832
Use calculator computer program for math class	1.206**	-2.375	1.636	4.611	-.290
Didactic: Use computer program to drill on math facts	-5.926***	-8.694***	-5.150	1.413	-6.391***
Constructivist: Use spreadsheet program for math assignments	-6.959***	-5.631**	-2.029	-7.045*	-5.627***
Constructivist: Use computer program for new lessons on problem solving	-1.042*	-3.471	-.796	-7.239*	-.931
Constructivist: Use internet to learn things for math class	.052	1.400	-2.630	-2.954	-.850
Constructivist: Use graphing program for charts for math class	-.621	-2.619	1.505	-6.575*	-.509

Constructivist: Use statistical computer program for math class	-9.613***	-5.518*	-14.956***	-6.959	-10.986***
Constructivist: Use word computer processing program for math class	-6.383***	-9.436***	.900	-1.584	-6.328***
Teacher Computer Usage: School					
Students use computer for four function calculator	-3.240***	.946	-8.591*	-9.676***	-5.879**
Student use computer use scientific calculator	.880***	-2.321	-7.642**	11.179***	7.998***
Students use computer use graphing calculator	7.550***	5.953**	5.345	7.551**	6.359**
Didactic: Students use computer practice or review math	1.672***	-5.161*	-9.347*	-2.912	6.843**
Didactic: Students use computer to play math games	-3.367***	1.588	4.644	1.183	.037
Constructivist: Students use computer extend math learning	.452	-.448	4.008	-4.957	-3.328
Constructivist: Students use computer research a math topic	.312	1.547	6.759	1.873	-2.825
Constructivist: Students use computer to draw geometric shapes	.111	-2.462	-1.554	10.813**	-4.923**
Constructivist: Students use computer use for graphing program	.202	2.689	-3.052	-5.956*	3.702
Constructivist: Students use computer email about math	5.353***	-3.387	11.772**	15.255***	4.933***
Teacher Computer Competency					
Prof dev-use of computers or other technology	-.178	2.652	1.166	-4.692	2.377
Constant Model 1					
	304.133	304.227	325.409	317.714	300.779
Constant Model 7					
	294.984	282.669	310.976	299.508	267.917
R Square Model 1					
	.254	.235	.384	.273	.205
R Square Model 7					
	.392	.405	.519	.495	.393
N Model 1					
	24,326	1,073	756	636	1,563
N Model 7					
	24,326	1,073	756	636	1,563

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

Summary

In order to analyze the effects of technology access, usage and competency on student achievement, this chapter provided a three phase approach to interpreting the data. The first phase of the analysis examined the normality of the predictors. Since a large percent of grade four and grade eight math students indicated that they did not use technology in the classrooms, the variables measuring technology usage exceeded the indicators of normality, and histograms illustrated heavily skewed responses. Due to this abnormality, it was determined the best method was to recompute the variables into dichotomous response choices. Next, a close examination of collinearity was assessed to determine if the variables were highly correlated with each other.

The second phase of the analysis consisted of descriptive statistics, which provided a summary of the basic features of the national, Large City and TUDA populations represented by the sample. Descriptive analysis found that throughout the nation and within urban school districts, the gap in access across students in both grade four and grade eight seemed to be minimal. However, those students who did not have access to computers scored significantly lower on standardized exams.

Home computer usage overall improved math scores for grade four and eight when the Internet was used at home; however scores declined when students used it for math homework or to email/message/blog to get math help. Unlike home computer usage, student reported classroom usage had mixed results. Classroom computer usage was different based on grade level, as grade four students typically used it technology for didactic approaches while grade eight students were more likely to use it for constructivist approaches. Didactic approaches seemed to benefit students in grade four; however, they lowered scores in grade eight.

The third phase of the data analysis used OLS to examine the relationship between access, usage and teacher competency in the classroom and student achievement while controlling for demographic variables. This approach was used to explore the six research questions guiding this study. The majority of variables associated with the use of technology reported by the student was found to have a negative relationship with student scores. At the national level, teacher reported technology use overall had a positive impact on student achievement; while Large Cities and TUDA had mixed results.

The concluding chapter will now provide insight into the implications of these results, the limitations to the analysis, and potential future research on technology and student achievement.

CHAPTER SIX: CONCLUSION

This conclusion provides a summary of the study including the statement problem and a brief review of the methodology. The conclusion also reviews the key findings, recapping the results discussed in Chapter Five, the implications of the six research questions, and the study's limitations and how they may have affected the results. The final section considers possibilities for future research to better understand the impact of computer technology in the home and at school and how this affects student achievement.

Summary of the Study

Access to computer technology, both hardware and software, has increased in homes and classrooms to promote learning in the 21st century (Ganesh and Middleton 2006). Accordingly, computers and related applications have become an important classroom tool to improve student learning (Vale and Leder 2004). Over the last decade numerous studies have been conducted to determine the impact of computer applications to promote learning in math. But the results have been mixed. On the one hand, studies have shown computer applications in classrooms have a significant positive impact on student motivation and math achievement (Warschauer et al. 2004; Warschauer 2011; O'Dwyer et al. 2012). Other research, however, has concluded that computer technology either has no impact or negatively affects student math outcomes (Sclater et al. 2006; Richtel 2011). Despite these conflicting findings, instructional technology continues to be promoted as essential to support students in the home, as well as a key element in classroom math instruction.

The objective of this study was to determine if student access and use of instructional technology is a significant predictor of fourth and eighth grade math achievement test scores. In doing so, the results can inform policy initiatives and educators about the most appropriate technology platforms to promote student learning.

Taking a quasi-experimental approach, the study analyzed the results of the 2011 fourth and eighth grade composite mathematics scores on the National Assessment of Education Progress (NAEP). The analysis focused on the academic performance of students in four Trial Urban Districts Assessment (TUDA), by comparing their scores to aggregated large city (LC) populations and the national sample after controlling for the effects of race, gender and socio-economic-status. The four TUDAs were selected based on racial demographics or technology focus and included the following: Chicago with a 50-50 population split of African-American and Hispanic students; the District of Columbia, with a predominantly African-American population; Miami, with a predominantly Hispanic population; and Boston, with a focus on a technology rich urban environment.

As a starting point the study assessed if there were differences in access and usage in computer technology in TUDA school regions compared to LCs and national populations. Where such differences existed, the analysis examined the effect it had on student composite math scores as measured by NAEP's math assessment. This study contributes to the existing body of research on educational technology by focusing on the effects of technology on student math achievement in specific urban populations. As technology resources increase it is important to determine which intervention strategies (e.g. access, usage and/or teacher computer competency) designed to improve student outcomes are the most effective in particular communities.

Key Findings

The math achievement gap has been well-documented among racial and ethnic groups, socio-economic-status (free or reduced lunch eligibility), and parental educational level. Findings from this research study support the literature in the field, and indicate that roughly 22 to 25 percent of the achievement gaps are associated with these demographic factors. While this is a known phenomenon, there are other contributory factors to the achievement gaps, which is the focal point of this study. The following key findings elaborate on the contributing effects of home and school access to and usage of computer technology as well as teacher computer competency.

The research findings indicate that there are differences in both access and usage based on grade and school location. Overall access to a computer at home and in the classroom improved grade four and eight student scores, while usage types had mixed results. Further analysis reveals that most *student-reported* variables associated with computer technology usage in the home and in the classroom decrease achievement, while *teacher-reported* variables associated with in-classroom usage had mixed results. A closer examination into the types of technology used in grade four and grade eight reveal that specific applications can significantly impact mathematic achievement across the nation, while in specific urban areas the particular application has little to adverse effects.

Since national education policies and funding continue to advance the promotion of technology in the home and classroom, the access gap has decreased substantially. Despite the availability of computers and access to the Internet, a majority of students in grade four and grade eight reported never using a computer in their math classroom. Those who did use computer applications primarily used them for didactic purposes and were less likely to use them for abstract constructivist purposes.

Overall, on the *student-reported* assessment, using computers at home and in the classroom had associated lower math scores for both grade four and grade eight. Based on the regression model at the national level, grade four students who reported using the computer for the following reasons had significantly lower test scores: at home for math homework, at school for math, to play math games (didactic), to make charts or graphs for math (constructivist), and to use the Internet to learn things about math (constructivist). Nationally, students in grade eight who reported using the computer for the following reasons also had decreased scores: for math homework, to email/message/blog to get math help, programs to drill on math facts (didactic), spreadsheet programs for math assignments (constructivist), new lessons on problem solving (constructivist), statistical applications (constructivist), and word processing (constructivist).

In contrast, an investigation of *teachers*' responses to computer applications in the classroom found different results for both grade four and grade eight. Grade four national numbers indicated an increase in scores when didactic approaches were used, while a majority of TUDA schools using this approach had decreased student scores. At the same time, grade four national numbers indicated a decrease in scores when constructivist approaches were used, which was also the case in TUDA regions.

Teachers' responses to computer technology for grade eight didactic and constructivist applications had different results. Students who used the computer to play math games, a didactic application had lower test scores at the national, LC and most of the TUDA regions, with the exception of D.C. where scores increased. Three constructivist applications -- drawing geometric shapes, graphing programs and emailing about math -- increased scores throughout the nation and in most TUDAs, a finding that is contrary to grade four results. One constructivist approach -- using the computer to research a math topic -- decreased scores at the national, LC, and within all TUDA populations, with the exception of D.C.

The results found that grade four teachers with a moderate to large extent of professional development in using computer technology were associated with lower scores nationally. However, when grade four teachers reported having training in specific areas – basic computers, software applications, the use of other technology and integrating computers into instruction – scores improved in LCs, Chicago and Boston. Results indicated a similarly positive relationship for the nation, LCs and Chicago for grade eight teachers who reported having a moderate to large extent of professional development.

Implications

Based on the relevant literature, there appears to be a gap in the research regarding how and to what extent technology application access and usage are related to academic achievement in LCs and TUDA populations. The purpose of this study was to determine if student access and use of instructional technology is a significant predictor of fourth and eighth grade math achievement scores. In terms of technology usage, this study's objective is to determine if there is a relationship between different applications – didactic and constructivist – and academic achievement among fourth and eighth grade students. Furthermore, the existing literature suggests that teachers' professional development associated with *Technology-Pedagogy-Content-Knowledge* (TPACK) can promote effective learning and increase test scores (Mishra and Koehler 2009; Niess et al. 2009). The following section presents a discussion on the effects of computer access, computer use and teacher professional development on student achievement in LC and TUDA populations.

Computer Access.

The first two (of six) research questions address how technology is distributed in the home and at school, and whether there are patterns of equitable access in terms of race, gender and socio-economic-status. Furthermore, they address if there is a relationship between access in the home and at school and student math achievement.

Results indicate that over 80 percent of grade four students reported having access to a computer both at home and in the classroom, and more then 60 percent had access to the Internet at school; access to handheld devices such as iPads was less common. Access was less of an issue for grade eight students; nearly 90 percent of all LC and TUDA students had an available computer in the home and in the classroom. Existing literature on the access divide claims that urban school areas (i.e. LC and TUDAs) and disadvantaged communities continue to have limited availability to computers and the Internet compared to national levels. However, these findings illustrate that the digital divide has decreased substantially and equality in computer access has been for the most part addressed in urban communities.

For grade four, results from the weighted regression model show that at the national and LC levels access to computers in the home and in the classroom was positively associated with test scores, while handheld devices had little effect, and access to the Internet had a negative relationship to student scores. Results indicate a statistically significant negative relationship between school access and student achievement in Boston and Miami, and a positive relationship to handheld devices and student achievement in D.C. Miami was selected for their Hispanic demographics, and further investigation found that a majority of students were classified as English Language Learners (ELL). A further investigation is needed to determine if ELL students have limited English reading comprehension, and thus lack the necessary skills to properly utilize technology in the home or classroom.

For grade eight, the weighted regression model illustrates that having computer access at home and in school positively affected students across the nation and in LCs. A majority of the TUDAs illustrate no statistical significance between access and student scores, with the exception of Chicago where results indicate a positive relationship between school access and student achievement. Chicago's positive results might have been attributed to their recent city-wide public school technology integration programs. These programs increased access to computers and the Internet for students across the urban region, increasing such resources may have been attributed to increase student achievement.

This study suggests that at the national level access to certain types of computer technology are associated with improved math achievement, while other variables are not. These results are important since educational policies continue to fund access-based programs that may not actually be beneficial to improving scores. For example, one way federal funding has increased computer technology access for students is by providing state-wide funding to provide one-to-one student to computer ratios, whereas schools offer handheld devices such as iPads and laptops for students to use in the classroom and to take home. This is consistent with research by Warschauer (Warschauer 2008) and Dunleavy and Heinecke (Dunleavy and Heinecke 2008) which found that one-to-one student to computer ratios promote student learning and increased scores. However, this study's regression model for TUDA schools does not support this finding, except for D.C. where having access is positively associated with test scores. The reason for better learning outcomes in D.C. may be due to more opportunities for teachers to "blend" technology into the curriculum to support student learning; this merits further study (Lautzenheiser and Hochleitner 2014).

Home Computer Usage.

One of the key findings of this study was that using the Internet at home increased math scores, while using the computer at home for math homework decreased student achievement in both grade four and grade eight. Furthermore, grade eight students who used email/message/blog to get math help also had decreased student achievement. These results were consistent during the independent t-test and OLS regression models for the national, LC and TUDA populations.

Findings from this study are consistent with some of the literature that examines home usage and student achievement. Several important research studies have found a positive relationship between student use of the Internet at home and student outcomes (Attewell and Battle 1999; Fairlie 2005; Wenglinsky 2005; Bebell and Kay 2010; Shapley et al. 2010). The related evidence suggests middle and upper income students with access to laptops, the Internet and math software at home utilize it to improve their understanding of the content in the classroom (Ching et al. 2005). While other studies suggest that lower-income students often use the Internet for recreational purposes, which has been strongly correlated with decreased test scores (O'Dwyer et al. 2012).

These results imply that TUDA students who were using the Internet for math help or to email/message their peers might have been struggling with the content of their math classes. As stated in the literature, students who use the Internet for math support do so in order to simply find a solution to their math problem. Thus, the student is not utilizing the Internet in order to develop their conceptual understanding of the math content, and has inappropriately utilize the technology resource (Bebell and Kay 2010; Shapley et al. 2010). Thus, using home computers to talk to peers and get math help might not be an essential tool for developing an understanding of math concepts.

Classroom Computer Usage.

Of particular interest for this study is the role that didactic vs. constructivist approaches to classroom technology have to student achievement. Both grade four and grade eight students and teachers reported using didactic approaches to technology more frequently than constructivist. Grade four students and teachers who reported using the computer in class to practice and/or drill on math facts, a didactic approach, had statistically significant higher student scores across the nation, in LCs, Boston and Miami. In contrast, however, playing math games, another didactic approach, actually lowered scores nationally and throughout LCs and in Boston.

Grade eight students typically applied didactic approaches to use the computer to extend math learning. Despite the level of frequency with these applications, the OLS regression models found that scores significantly decreased when students used computers to practice/review math (didactic), to play math games (didactic) in D.C. and Miami; and to extend math learning (constructivist) in Boston. Less frequently used constructivist applications, such as to research a math topic, increased scores in LCs, DC, Boston and Miami.

The literature suggests that the use of technology in the classroom has a variable relationship with student achievement in mathematics based on the type of usage employed (Cuban et al. 2001; Dynarski et al. 2009; Lei and Zhao 2009; Bebell and Kay 2010). Didactic applications of computers in elementary school settings are more beneficial as students are still learning basic math facts and drilling on those facts provides useful to long-term memorization (Tienken and Maher 2008). These approaches are primarily to reinforce methods of instruction that are given during class, and are not intended to replace teaching.

In contrast, research findings illustrate a negative relationship between the use of didactic approaches in middle and high school student outcomes (Wenglinsky 2005). Findings suggest that middle and high school teachers who have a difficult time implementing technology into classroom instruction, fall back on didactic methods. For example, teachers who use computers for “lower-order” tasks, such as drill and practice often create ‘uninspired’ classrooms that do not promote and engage student learning (Cuban et al. 2001). Furthermore, this research indicates that the use of computers to review math or play math games do not provide a setting for students to acquire content knowledge and apply it during standardized exams. Constructivist approaches such as researching a math topic likely provide a more engaging and intellectually stimulating environment, motivating students to learn. In addition, research suggests that higher order processing applications are positively associated with constructive and abstract learning which increases student achievement (Wenglinsky 2005; Lei and Zhao 2009; O'Dwyer et al. 2012).

A major implication of computer usage in the classroom is the awareness that different technology interventions for academic improvement should be considered based on the demographic and social contexts of the students. Technology applications can furnish positive learning outcomes for students in urban and/or disadvantaged areas; however, before utilizing the approaches it is essential to determine the ability and needs of those students. As illustrated in these findings, approaches to technology usage outcomes varied in different social contexts, and thus similar approaches to technology is not the most beneficial approach to achieve positive outcomes; rather technology should be used as a flexible resource to support different learning situations.

Teacher Professional Development.

The final research question addressed the link between teachers' professional development and technology training to student achievement, with the assumption that more training would improve their use of technology and increase student scores. At the national and LC populations, roughly one-third of grade four teachers attended professional development courses on the use of computer technology. While a minority of teachers had taken such courses, a majority (over 50 percent) of the teachers surveyed felt that they were proficient in basic computers, software applications, the use of the Internet, the use of other technology and training in integrating computers into instruction. For the national and LC populations those teachers who self-identified as being competent had students with statistically significant higher scores.

Although these results were consistent at the national and LC populations, results varied greatly for the TUDA regions. Overall teachers in all the TUDA regions were less likely to have professional development courses compared to those at the national and/or LC populations. In Boston, a technology rich environment, teachers were less likely than other TUDA regions to be trained in software applications, the use of technology, and integrating computers into instruction. Although Boston students outperformed other TUDA regions, those who had teachers with less training scored lower on the standardized tests than the average for the TUDA regions.

In addition, Chicago teachers who were trained in software applications and the use of other technology had students with significantly higher math scores. Lastly, Miami teachers who had training in software applications, the use of the Internet and integrating computers into the classroom had students with significantly higher math scores. While in D.C., teachers with training in basic computers had substantially lower scores, thus D.C. generally performed worse than the other TUDAs even if the teachers were trained.

Similar results from the independent t-tests were found when the OLS regression were analyzed. At the national level, all teacher computer competency variables improved scores, except for training in the use of Internet. At the LC level, teachers who were trained in software applications and the use of other technology saw an improvement in student scores. At the TUDA level, the most influential variables for D.C. included professional development, training in basic computers, in the use of other technology and integrating technology into the curriculum. In Chicago and Boston students were most impacted by teachers with training in software applications. Miami students were most affected by teachers who had training in proper integration of computers into instruction. These findings suggest that professional development for grade four teachers is a critical component for improving technology integration to promote student achievement. Although these results suggest that high quality professional development programs are perennial, there continues to be a shortage of programs for TUDA grade four teachers.

Grade eight teachers were only asked one question regarding their professional development in terms of computers or other technology. A majority of teachers at the national level had a moderate to large extent of professional development courses, and students scored higher with teachers that had this background. Similar findings are present in LC and TUDA regions; scores significantly rose if students were in classrooms with teachers that had a moderate to large extent of professional training, with the exception of Boston where scores decreased.

These results are significant since they are consistent with studies that indicate teachers with higher proficiency and competency to utilize computer software as an integrative tool for educational learning will significantly improve student achievement (Silvernail and Lane 2004; Silvernail and Buffington 2009; Shapley et al. 2010). Furthermore at the national level these findings support the TPACK framework which stipulates that teachers with professional development and training in computer applications can successfully integrate technology into their specific content (i.e. math) curriculum. Thus, teachers who responded to having a proficient training or felt confident in Pedagogical Knowledge (PK) and/or the Content Knowledge (CK) Technology Knowledge (TK) had increased student outcomes at the national level (Mishra and Koehler 2006).

Although these findings are supported at the national level, LC and TUDA populations reported varying effects of teacher computer competency and student achievement. Even though a majority of urban teachers reported being competent in computer integration and proficient in technology, most of these skills did not translate to significantly improved students scores. This means that when controlling for urban areas and demographic variables (i.e. race, gender and socio-economic status), the overall impact of teachers' participation in professional development or training in programs in various technology applications was not related to math student outcomes.

This might be attributed to the view that computer technology integration into the classroom is a "universally applicable skill" that can be learned by "acquiring *basic competency* with hardware and software packages" (U.S. Department of Education 2010). Despite these claims, "basic skills" might not address the content-specific needs of math computer technology integration. Many professional development program initiatives have been focused on increasing overall technology awareness, with content-neutral software applications that run across all content and pedagogical contexts (Darling-Hammond et al. 2009). Mishra and Koehler (Mishra and Koehler 2007) found that teachers' pre-service and professional development workshops often provide only standard techniques or stand-alone technology courses that are "self-contained". Thus what is taught in pre-service programs or professional development workshops is often not applicable to the actual content of the classroom. They found that most programs and workshops for technology use in the classroom become an issue for the following reasons:

- technology rapidly changes becoming outdated quickly, and providing training on current software, hardware and terminology can make knowledge too specific to be applied broadly;
- software is often inappropriately designed for the specific audience it is servicing;
- context-neutral approaches to technology integration encourage generic solutions to the problem of teaching, particularly in disadvantaged areas; and
- technology programs focus on what basic technology skills teachers should

> know, and not how they should apply them in the classroom; teachers who attend these programs accumulate inert facts instead of how to integrate the applications into their classroom.

Thus, a potential implication for educational policy is to construct a more successful approach to teacher training by developing a specific TPACK model to address the challenges of technology implementation and integration in the math classroom (Mishra and Koehler 2009). Teachers with a richer learning environment could develop a better connection between content, pedagogy and technology to use their knowledge, instructional practices and understanding of math while integrating various technologies into their daily lesson plans to be more effective and improve student learning outcomes.

Limitations

As summarized in Chapter One, there are limitations of this study that are important to recognize. First, there were a limited number of technology-focused questions in the NAEP, and many were broad and general without asking which specific software applications were utilized. For example, it was not clear how students "used the internet" and whether they accessed programs such as Khan academy to explain math concepts. These types of questions should have follow-up open-ended questions to determine the types of applications being utilized while on the Internet in order to judge the effectiveness of the approach.

Second, the ways in which this study applies didactic and constructivist instruction leads to a restricted set of features for both approaches. For future research studies examining a more comprehensive set of practices related to the two types of instruction might be useful to determine more specific features of instruction and to identify more fundamental instructional issues and larger structural inequalities, e.g., school funding for technology. Nevertheless, the themes and definitions associated with didactic and constructivist approaches in the literature (e.g., drill and practice, review of math and so forth) are emphasized in this study and represent similar meanings.

Third, part of this study is based on students' and teachers' self-reported measures of technology usage over the course of the academic year; their respective recollection of technology practices over the proceeding year may have been inaccurate, causing the results to be skewed. Moreover, teachers might have felt pressured to portray a certain type of instructional practice, which could have affected their responses. In order to strengthen future analysis it would be helpful to include qualitative observations in the classroom over the course of the academic year.

Fourth, the method used to dichotomize the independent variables impacted the results as response choices were minimized, resulting in a loss of precision. By collapsing variables, the response choices no longer represented different levels of usage, rather only if someone used the program or not. Thus results did not indicate the frequency of usage (e.g., every day, almost every day, once a week and so forth) and dichotomizing the response choices altered the capacity to determine levels of differences.

Fifth, the statistics used in this study were correlations, independent t-tests, ANOVAs and OLS regressions. Accordingly, these methods did not infer causal relationships between technology and student outcomes. Future studies should use a longitudinal experimental design in order to address the causal nature of the relationship between technology and achievement outcomes over time.

Lastly, the generalization of the findings, based on technology and student achievement in elementary and middle public schools in specific TUDA regions, needs to be interpreted with caution. Since the results varied by TUDA region, the relationship of instructional technology to student achievement may be moderated by factors such as demographics, student skill level, urban technology programs, and the experience of the teachers. To improve the generalizability of the design of this study, future research should assess all urban areas, as well as high school outcomes (Becker 2001; Barron et al. 2003; Antonietti and Giorgetti 2006; Dunleavy and Heinecke 2008; Cuban 2009; Bebell and Kay 2010).

Future Research

This study's results have significant implications for the future of technology policy and practice. As discussed in the literature review (Chapter Three), a number of educational reform initiatives have been based on important assumptions about the ways in which technology is used and the impact of such use on academic performance of a diverse set of learners. The findings reveal that technology cannot be used as a general approach to improve scores. Given this conclusion, five areas for future research are identified which would inform education policy related to the specific use of technology.

First, the *type* of home computer usage would provide useful insights on the effects of computer technology and student math achievement. Previous studies have illustrated that disadvantaged groups are more likely to utilize computers at home for unproductive purposes such as playing non-educational games, while students with higher socio-economic status including educated parents, use home computers for more educational purposes. Future studies should monitor home frequency and usage with specific focus on the type of programs, recreational or educationally-driven, being employed at home.

Second, there is need for further research on the *specific applications* of computer technology that increase math achievement scores. This research is limited to the specific variables used by NAEP and only general approaches to math technology instruction were examined. Identifying the most appropriate computer software methods can help school districts select the programs best suited for their students, as well as to ensure that relevant federal funding is effectively used. In particular, policy reform programs should focus on high-poverty, urban and rural schools that typically primarily use didactic drill-and-practice software packages which often results in students only learning the basics and not developing higher-order thinking skills.

Third, educational technology advocates have argued that technology in the classroom can positively affect student achievement, depending on how the student utilizes the technology for learning. Technology-based assessments in this study are broad, generalized and do not provide an in-depth assessment of what students know and can do when they engage with technology to approach problem solving. A future research project should include a *framework for assessing the technology literacy*, *knowledge and skills* of the student and teacher. Such a structured assessment would help gauge how students effectively apply technology concepts to real-life situations that involve specific content areas.

Fourth, studies have illustrated that pre-service and in-service professional development and computer technology training is essential for proper integration of technology for learning in the classroom. Results have also shown a significant correlation between teachers' computer competency and improved student scores. This study finds that most teachers felt competent in technology. However, not only did they not use technology frequently, the level of their professional development did not widely affect scores. To determine which technique is most effective for training teachers (e.g., intensive weekend seminars, semester-long courses, etc.) more *in-depth research on professional development and computer competency* should be carried out.

Lastly, researchers and policy makers would greatly benefit from a better assessment of *causation*. Quasi-experimental studies such as this dissertation may be useful for focusing the experimental design of such studies on key areas of potential analysis. Accordingly, future research should construct a true experimental design which would involve the identification of a randomized treatment group and a control group (students not exposed to in-school computer applications). A pre-test to determine the level of the students' math ability and post-test following the intervention could yield interesting insights on the impact of different interventions. For instance, such an experimental approach could examine whether students in remedial math classes receive the most benefit from didactic approaches, while students in more advanced math courses (or have a better understanding of math concepts) benefit more from constructivist approaches. This experimental approach would reveal the types of programs that are useful by grade and ability level.

Conclusion

The study's objective was to examine the differential effects of computer access at the home and in classrooms, computer usage reported by students and teachers and teachers' professional development/computer competency on student achievement. The analysis of NAEP data, adjusted for a series of individual demographic background factors, generated the following results:

i. race, income and parent educational level continue to attribute a majority (25-30 percent) of the differences in standardized scores for both grade four and grade eight;
ii. access to computers both at home and in the classroom strongly correlate with higher math scores;
iii. didactic approaches were more likely to be used in both grade four and grade eight classrooms than constructivist approaches;
iv. didactic approaches to math benefited students in grade four but decreased scores for grade eight;
v. teacher computer competency and professional development only marginally affected scores; and
vi. the impact of technology integration methods did not affect all areas in the same manner - LC and TUDA schools were impacted differently compared to national populations.

Based on these findings, the overall implication of this research is that individual demographic characteristics such as race, socio-economic-status and parent education level remain the most important predictors of academic success. While technology access, usage and computer competency were found to have a significant effect on student outcomes, the effect was smaller compared to the demographic predictors. Reform policies continue to reshape public education by addressing demographic disparities, and by providing additional resources to minorities to promote equality. However, these policies have not sufficiently remedied the problems imposed by the social stratification issues. Educators have turned to other avenues such as technology to support learning. But over-simplistic approaches to technology integration in public schools have not closed the achievement gap. The results of this study underscore the need to reform technology policies and computer-related instruction to provide new approaches to support student learning and prepare educators on how to properly utilize technology.

Increasing technology resources in the home and in the classroom without providing effective integration techniques does not produce more efficient or knowledgeable students (Tolmie 2001). Instead, reform policies should reflect technology integration based on empirically-founded programs that support learning, improve scores and offer support to teachers. Technology innovations should incorporate:

i. active learning and teaching communities that involve supporting technology pedagogy;
ii. technology applications that are adopted based on student learning levels; and

iii. the creation of motivations for students to use technology for learning objectives.

In conclusion, this study provides useful guidance to policymakers and educational researchers about the future role of technology in educational reform. It addresses the most effective ways technology can benefit student achievement for grades four and eight. And, it identifies areas needing greater research. This study's results and proposed areas for future research will help create the basis for computer technology to fulfill its educational promise.

APPENDIX I: HISTORICAL TIMELINES OF THE REAUTHORIZATION OF THE FEDERAL ELEMENTARY AND SECONDARY EDUCATION ACT

1965 Elementary and Secondary Education Act (ESEA)

1981 Reauthorization of the Elementary and Secondary Education Act (ESEA)
The name changed to Education Consolidation and Improvement Act (ECIA)

1988 The Elementary and Secondary Education Act (ESEA) reauthorization
The name changed to Augustus F. Hawkins-Robert T. Stafford Elementary and Secondary School Improvement amendments

1994 The Elementary and Secondary Education Act (ESEA) reauthorization
The name changed to Improving American Schools Act (IASA)

2001 The Elementary and Secondary Education Act (ESEA) reauthorization
The name changed to No Child Left Behind Act of 2001

2002 The Elementary and Secondary Education Act (ESEA) reauthorization appropriated its first fiscal year funds for the Enhancing Education Through Technology (EETT) Act, Title II, Part D of the No Child Left Behind Act of 2001

2010 Obama Reauthorization of the ESEA, March 13, 2001, Blueprint for Reform

APPENDIX II: DEMOGRAPHICS OF STUDENTS

Ethnicity/Race

The study will examine ethnicity/race and utilized the pre-defined race categories set by NAEP. Students select their race based on the following identifying choices:

1. Hispanic or Latino-Mexican/Mexican American/Chicano;
2. Hispanic or Latino-Puerto Rican/Puerto Rican-American;
3. Hispanic or Latino-Cuban/Cuban-American;
4. Hispanic or Latino-Other;
5. American Indian/Alaskan Native;
6. Native Hawaiian/Other Pacific Islander;
7. White;
8. Black or African-American; and
9. Asian

Gender

1. Male; and
2. Female

Economic Status

A combined measurement will be used to determine economic status. First, the study will examine if the student is eligible for the National School Lunch Program (NSLP). There are two categories for those students that meet the eligibility requirements - they are either on free or reduced priced lunch programs. Based on the income eligibility guidelines, students who receive either free school meals are living in a household that the gross income is not greater than 130 percent of the Federal Poverty Guidelines. Based on the income eligibility guidelines, students who receive either reduced priced school meals are living in a household that the gross income is between 130 percent and 185 percent of the Federal Poverty Guidelines.

Community Status

The community status of a school is based on three indicators which are defined by the National Association of Governing Boards and the United States Census. The categories for school community status are: urban, suburban, or rural. This study will focus on four specific urban school districts defined by TUDA eligibility criteria.

APPENDIX III: DEFINITION OF TERMS

Definitions of the following terms have been made to provide clarity and operationally for the purpose of the study.

Academic Index. scores that schools have to report that compare them to other schools in the state. All schools are required to reach 100% proficiency for all students on reading and mathematics state assessments by 2014.

Accountability. The responsibility for actions, decisions, and policies that directly affect test scores which schools are obligated to report, explain, and be answerable for resulting academic standards.

Achievement Gap. An achievement gap describes differences on measurements seen on various dropout rates, grade point averages (GPAs), state and national standardized tests, ACT and SAT scores, college enrollment and so forth. These disparities are observed between groups based on demographics such as gender, ethnicity/race and socio-economic status (SES).

Adequate Yearly Progress (AYP). This measurement was defined by NCLB which establishes state standardized tests to compare how public schools students are achieving academically to other schools within the school district (U.S. Department of Education 2001). State officials must disaggregate student achievement data by subgroups to ensure that each child is learning. The results from the achievement data, as defined by the state leaders, assist in determining how students are progressing toward the national educational standards (No Child Left Behind, 2002).

Charter School. An independent K-12 public school program which is constructed and operated by community leaders, educational leaders, organizations, teachers and parents.

Elementary and Secondary Act of 1965 (ESEA). Public Law 89-10 passed on April 9, 1965, as a part of President Lyndon B. Johnson's "War on Poverty"; designed to address the problem of inequality in education that existed after the passing of the Civil Rights Act of 1964

Highly Qualified Teacher. NCLB created a federal definition of “highly qualified” teachers by setting a criteria which included a minimum of full state certification, a bachelor’s degree and level of proficiency in the subject matter the teacher is teaching in (U.S. Department of Education 2001).

Instructional technology (IT). Refers to the introduction of computers and related pieces of equipment to the classroom (Wenglinsky, 1998). This incorporates all instructional practices that include computer related equipment (i.e. computer hardware), or software (i.e. web-based applications) that students use to achieve instructional objectives.

Interactive technology. Interactive learning occurs when the source of instruction is communicating directly with the learner and is shaping responses to the learner’s needs. Tutoring, or a teacher teaching a single student, is an example of highly interactive learning. Interactive technology such as computers and other modern technological applications is a venue in which, theoretically, the ability to provide effective interactive instruction to any learner on any subject exists (Association for Supervision and Curriculum Development, 2009).

Minority. A sociological group that typically is classified as disadvantaged in regards to workforce, economic status, education and so forth. Characteristically subgroups that fall into minorities represent a population that is a numeric minority as well.

NAEP Achievement Levels (three): Performance standards set by the National Assessment Governing Board that provide a context for interpreting student performance on NAEP, based on recommendations from panels of educators and members of the public. The levels, *Basic*, *Proficient*, and *Advanced*, measure what students should know and be able to do at each grade assessed.

No Child Left Behind. Public Law 107-110. This act was established in 2001 in order to close the achievement gap with accountability, flexibility, and choice, so that "no child is left behind".

No Child Left Behind State Strategies and Practices for Educational Technology: Volume I- Examining the Enhancing Education Through Technology Program. The volume provides a detailed list of practices and strategies for each individual state and their school districts to effectively establish and implement the EETT program.

No Child Left Behind State Strategies and Practices for Educational Technology: Volume II- Supporting Mathematics Instruction with Educational Technology. This volume provides a detailed list of practices and strategies for states to effectively implement the EETT program in classrooms during mathematics instruction.

No Child Left Behind State Strategies and Practices for Educational Technology: Volume III- Supporting Reading and Writing Instruction with Educational Technology. This volume provides a detailed list of practices and strategies for states to effectively implement the EETT program in classrooms during reading, literacy, and writing instruction.

Pedagogy. This is the method and principles teachers use during instruction.

Socio-Economic-Status (SES). This is a measurement used both in economics and sociology to define various interconnected characteristics of an individual such as economic status, educational level, income, occupation, etc.

Teacher Preparedness on Subject Matter. Utilizing Wenglinksy (Wenglinsky 2005; U.S. Department of Education 2014u8230?) definitions, this term measures teachers on the basis of the following: teacher background, training/professional development, years of teaching experience, certifications, degrees, major and minor field of study, course work in education, course work in specific subject areas, the amount of in-service training, and the extent of control over instructional issues.

Teacher Preparedness on Computers. Utilizing Wenglinksy (Wenglinsky 2005) definition, this term measures whether teachers have received professional development on how to use computers in the classroom. Furthermore, it describes the teachers level of “comfort”, proficiency, confidence and competence to integrate the computer into the classroom.

Title I. Resulting from the Elementary and Secondary Education Act of 1965, the

United States Department of Education provided additional funding to schools and school districts with poverty rates of 40 percent or higher (Henke et al. 2000). Schools or districts that receive funding from Title I are managed by the federal and state government's *No Child Left Behind Act* (U.S. Department of Education 2001). The school or district can allocate the funds to be used for extended school programs, teachers' professional development and/or supplemental instruction (i.e. computers, software, etc.).

APPENDIX IV: TRIAL URBAN DISTRICT ASSESSMENTS (TUDA) DISTRICTS

The study examined 21 U.S. Department of Educational, Institute of Education Sciences NAEP-TUDA participating urban districts.

TUDA Eligibility Requirements
The following are TUDA's eligibility requirements which are followed by this study.

1. Only cities having 250,000 or more population
2. Districts participating in TUDA shall have a student enrollment large enough to support NAEP assessments in three subjects in each each grade assessed. The enrollment requirement is a minimum of approximately 1,500 students per subject per grade level assessed.
3. Districts participating in TUDA shall have an enrollment district-wide or in the grade levels assessed that meets at least one of the following criteria:
    a. 50 percent or more are minority students (i.e., African-American, American Indian,, Asian, Hispanic, Native Hawaiian, and/or multi-racial)
    b. 50 percent or more are eligible for participation in the free and reduced price lunch program (or other appropriate indicator of poverty status).

APPENDIX V: SAMPLE POPULATION: 2011

Student sample sizes and target populations for Trial Urban District Assessment (TUDA) in mathematics at grade 4, by jurisdiction: 2011

Jurisdiction	Sample size	Target population
Albuquerque	1,700	7,000
Atlanta	1,900	4,000
Austin	1,900	7,000
Baltimore City	1,500	6,000
Boston	1,800	4,000
Charlotte	1,700	11,000
Chicago	2,400	29,000
Cleveland	1,400	3,000
Dallas	1,800	13,000
Detroit	1,200	5,000
District of Columbia (DCPS)	1,500	3,000
Fresno	1,900	6,000
Hillsborough County (FL)	1,700	15,000
Houston	2,800	16,000
Jefferson County (KY)	2,000	8,000
Los Angeles	2,400	44,000
Miami-Dade	2,700	24,000
Milwaukee	1,400	5,000

New York City	2,500	71,000
Philadelphia	1,600	12,000
San Diego	1,700	9,000
Total for 21-School Districts	39,500	302,000

Student sample sizes and target populations for Trial Urban District Assessment (TUDA) in mathematics at grade 8, by jurisdiction: 2011

Jurisdiction	Sample size	Target population
Albuquerque	1,200	6,000
Atlanta	1,400	3,000
Austin	1,500	5,000
Baltimore City	1,100	4,000
Boston	1,300	4,000
Charlotte	1,500	9,000
Chicago	2,000	27,000
Cleveland	1,100	3,000
Dallas	1,500	10,000
Detroit	1,500	4,000
District of Columbia (DCPS)	1,400	2,000
Fresno	1,300	5,000
Hillsborough County (FL)	1,400	14,000
Houston	2,100	12,000
Jefferson County (KY)	1,400	7,000
Los Angeles	2,100	41,000
Miami-Dade	2,600	25,000

Milwaukee	1,200	5,000
New York City	2,300	74,000
Philadelphia	1,300	10,000
San Diego	1,200	8,000

APPENDIX VI: TOLERANCE AND VIF VALUES

Table 35: National Public Grade Four: Tolerance and VIF Values of Independent Variables

NAEP Variables	Collinearity Statistics	
	Tolerance	VIF
Home Access		
Computer in the home	.600	1.667
School Access		
Pct classrooms w/computer: gr 4 math	.364	2.748
Pct classrooms with Internet: gr 4 math	.366	2.730
Pct classrooms w/computer printer: gr 4 math	.905	1.106
Handheld devices (e.g., PDAs)	.970	1.031
Student Home Usage		
Use Computer at home for math homework	.864	1.157
Use the Internet at home	.593	1.685
Student Classroom Usage		
Use computer at school for math	.862	1.160
Didactic: Use computer to practice or drill on math	.779	1.284
Didactic: Use computer to play math games	.815	1.228
Construct: Use computer to make charts or graphs for math	.920	1.086
Construct: Use the Internet to learn things about math	.793	1.260
Teacher Classroom Usage		
Availability of computers for teacher/students	.896	1.116
Students use computer to use 4-function calculator	.900	1.111
Didactic: Students use computer to practice/review math	.389	2.574
Didactic: Students use computer to play math games	.479	2.090
Constructivist: Students use computer to extend math learning	.403	2.479
Constructivist: Students use computer to research a math topic	.688	1.453
Constructivist: Students use computer to draw geometric shapes	.727	1.375
Teacher Computer Competency		
Prof dev-use of computers or other technology	.821	1.218
Training in basic computers	.527	1.896

Training in software applications	.635	1.575
Training in use of the Internet	.499	2.005
Training in use of other technology	.662	1.511
Training in integrating computers into instruction	.633	1.580

Table 36: National Public Grade Eight: Tolerance and VIF Values of Independent Variables

NAEP Variables	**Collinearity Statistics**	
	Tolerance	**VIF**
Home Access		
Computer in Home	.566	1.768
School Access		
Availability of computers for teacher/students	.943	1.061
Student Home Usage		
Use the Internet at Home	.563	1.776
Use Computer at home for math homework	.789	1.268
Use e-mail/message/blog-get math help	.840	1.191
Use e-mail/message/blog-talk w/friends about math	.888	1.126
Student Classroom Usage		
Use computer at school for math	.786	1.272
Time per day on computer for math work	.799	1.251
Use calculator program for math class	.689	1.450
Didactic: Use program to drill on math facts	.552	1.810
Constructivist: Use spreadsheet program for math assignments	.683	1.465
Constructivist: Use program for new lessons on problem-solving	.550	1.819
Constructivist: Use Internet to learn things for math class	.637	1.571
Constructivist: Use graphing program for charts for math class	.567	1.764
Constructivist: Use statistical program for math class	.536	1.865
Constructivist: Use word processing program for math class	.619	1.615

Teacher Classroom Usage		
Students use computer-use four-function calculator	.858	1.166
Students use computer-use scientific calculator	.875	1.143
Students use computer-use graphing calculator	.826	1.211
Didactic: Students use computer-practice or review math	.470	2.126
Didactic: Students use computer-play math games	.644	1.552
Constructivist: Students use computer-extend math learning	.447	2.237
Constructivist: Students use computer-research a math topic	.708	1.412
Constructivist: Students use computer-draw geometric shapes	.750	1.333
Constructivist: Students use computer-use graphing program	.668	1.496
Constructivist: Students use computer-e-mail about math	.859	1.164
Teacher Computer Competency		
T087708 Prof dev-use of computers or other technology	.887	1.128

APPENDIX VII: RESULTS FOR INDEX

This appendix section examines the creation of the composite technology indexes for access, usage and teacher computer competency in grade four and grade eight. The index was created in order to examine if a combination of variables at each area of focus could potentially improve the performance of student scores. The composite indicators were formed by combining individual variables into a single index on the basis of the underlying model. Each of the composite indicators measured multi-dimensional concepts which could not be captured by a single predictor, e.g. combination of didactic or constructivist approaches. In general, composite indexes help to identify common trends across many separate predictor variables, and help to benchmark the usefulness of a set of combined variables. However, since the index did not improve the OLS regression model, it was moved to the appendix.

Composite indexes for grade four and grade eight were selected based on a series of analytical assessments, measurability, and relevance to the area (i.e. access, usage, and competency) being measured relative to student achievement. These indicators were derived from a series of observed facts that revealed significant outcomes when measured separately at the national level. The composite indexes were created as an aggregated variable computed based on a series of variables, and produced one new variable.

For grade four, the construction of the composite indicators were computed based on the following models:

1). Home Access: Computer at home (B017101)

2). School Access: Percent classrooms with computer (C071507) + Percent classrooms with Internet (C071508) + Handheld devices (C071511)

3). Student Home Usage: Use the Internet at home (M820401) + Use computer at home for math homework (M823901)

4). Student Classroom Usage (Didactic): Use the computer at school for math (M814301) + Use computer to practice or drill on math (M814601) + Use computer to play math games (M814701)

5). Student Classroom Usage (Constructivist): Use the computer at school for math (M814301) + Use computer to make charts or graphs for math (M814501) + Use the Internet to learn things about math (M814901)

6). Teacher Classroom Usage (Didactic): Availability of computers (T088301) + Students use computer to practice/review math (T106601) + Students use computer to play math games (T106609)

7). Teacher Classroom Usage (Constructivist): Availability of computers (T088301) + Students use computer to extend math learning (T106602) + Students use computer to research a math topic (T106603) + Students use computer to draw geometric shapes (T106606)

8). Teacher Computer Competency One: Training in use of other technology (T097504) + Training in integrating computers into instruction (T097505)

9). Teacher Computer Competency Two: Training in basic computers (T097501) + Training in software applications (T097502) + Training in use of the Internet (T097503)

Corresponding to these computations, Table 37 illustrates the ANOVA assessment, which revealed the more home and school access a student has the higher their scores are on the math section of NAEP. In terms of usage, students who reported using more didactic and constructivist approaches had lower scores. Interestingly, teachers who reported using more didactic and constructivist approaches in the classroom had students with higher test scores. Both teacher computer competency indexes illustrated the more competent a teacher is in technology the higher students will score on the standardized exam. To review all grade four LC and TUDA Analysis of Variances and Bonferroni measurements for indexes refer to Appendix VI: Tolerance and VIF Values.

Table 37: Analysis of Variance: National Grade Four Index

Indexes	N	Mean	Std Dev	df	t	F
Student Home Access						
No, I do not have a computer	22,381	226.97***	26.734	195,124	-71.660	20.509
Yes, I do have a computer	172,745	240.95***	27.558			
School Access Index						
No, I do not have Access	5,430	235.36***	28.877	186,285	-	78.240
Answered "Yes" to one variable	5,706	235.97***	28.008			
Answered "Yes" to two variables	100,442	239.91***	27.854			
Answered "Yes" to three variables	74,711	239.64***	27.684			
Student Home Usage Index						
No, I did not use the computer	27,179	229.05***	26.675	180,535	-	3946.833
Answered "Yes" to one variable	117,064	243.84***	27.007			
Answered "Yes" to two variables	36,295	234.98***	28.751			
Student School Didactic Usage Index						
No, I do not use these didactic approaches	39,106	240.60***	26.535	194,150	-	200.000
Answered "Yes" to one didactic variable	87,443	240.33***	27.494			
Answered "Yes" to two didactic variables	63,275	237.82***	28.591			
Answered "Yes" to all three didactic variables	4,330	233.10***	31.430			
Student School Constructivist Usage Index						
No, I do not use any of thse constructivist approaches	59,663	243.53***	26.169	192,400	-	1715.454
Answered "Yes" to one constructivist variable	68,691	240.84***	27.145			
Answered "Yes" to two constructivist variables	49,021	236.36***	28.434			
Answered "Yes" to all three constructivist variables	15,029	227.14***	30.287			

Teacher School Didactic Usage Index						
No, I do not use any of these didactic approaches	999	230.94***	29.649	184,106	-	48.374
Answered "Yes" to one didactic variable	23,557	238.94***	28.511			
Answered "Yes" to two didactic variables	23,297	240.67***	28.175			
Answered "Yes" to all three didactic variables	136,257	239.61***	27.511			
Teacher School Constructivist Usage Index						
No, I do not use any of thse constructivist approaches	1,009	230.67***	29.167	183,634	-	56.245
Answered "Yes" to one constructivist variable	48,286	240.20***	27.813			
Answered "Yes" to two constructivist variables	76,258	239.79***	27.473			
Answered "Yes" to all three constructivist variables	36,106	239.95***	27.867			
Teacher Computer Competency Index One						
No, I have not received any of these training's	29,193	236.88***	28.495	188,971	-	201.286
Answered "Yes" to one training variable	56,323	238.88***	27.785			
Answered "Yes" to two training variables	103,458	240.43***	27.534			
Teacher Computer Competency Index Two						
No, I have not received any of these training's	14,281	236.66***	28.641	188,016	-	82.814
Answered "Yes" to one training variable	12,668	238.41***	27.409			
Answered "Yes" to two training variables	35,363	238.69***	27.791			

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

For grade eight, the composite indicators were computed based on the following models:

1). Home Access: Computer at home (B017101)

2). School Access: Availability of computers for teachers/students (T088301)

3). Student Home Usage: Use the Internet at home (M820401) + Use computer at home for math homework (M823901)

4). Student Classroom Usage (Didactic): Use computer program to drill on math facts (M816101)

5). Student Classroom Usage (Constructivist): Use computer program for new lessons on problem solving (M816201) + Use Internet to learn things for math class (M816301) + Use word computer processing program for math class (M816701)

6). Teacher Classroom Usage (Didactic): Students use computer to practice or review math (T112601)

7). Teacher Classroom Usage (Didactic): Students use computer to play math games (T112609)

8). Teacher Classroom Usage (Constructivist): Students use computer to extend math learning (T106602) + Students use computer to research a math topic (T106603) + Students use computer to draw geometric shapes (T106606) + Students use computer e-mail about math (T112608)

9). Teacher Computer Competency: Professional development use of computers or other technology (T087708)

Corresponding to these computations, Table 38 illustrates the ANOVA assessment, which revealed similar findings as grade four. First, students scores increased when they reported having access to a computer in the home and at school. Second as students reported an increase in didactic and/or constructivist approaches to classroom technology, their scores decreased. These indexes followed similar trends to grade four indexes of access and student reported usage. Although, similarities existed with student usage indexes across grade levels, teacher reported usage differed in grade four and grade eight.

Grade four teachers who reported using didactic approaches in the classroom had increased student scores; however, those same in approaches in grade eight corresponded with decreased scores. Grade eight constructivist indexes produced mixed results, as scores rose significantly if teachers used three of the four variables (M=285.68, SD=35.28) and then sharply fell when all four constructivist variables were used (M=278.60, SD=36.722). This result might be an indication that some constructivist approaches are not beneficial to grade eight math curriculum. To review all grade eight LC and TUDA Analysis of Variances and Bonferroni measurements for indexes refer to Appendix VI: Tolerance and VIF Values.

Table 38: Analysis of Variance: National Grade Eight Index

Indexes	N	Mean	Std Dev	df	t	F
Student Home Access						
No, I do not have a computer	12,533	261.05***	32.186	160,746	69.300	106.566
Yes, I do have a computer	148,215	283.16***	34.471			
School Access Index						
No, I do not have Access	1,229	277.66***	37.878	148,414	-	55.153
Yes, available	124,473	282.52***	34.552			
Yes, I have access	22,713	280.16***	34.696			
Student Home Usage Index						
No, I did not use the computer	7,667	269.64***	32.181	150,907	-	2317.918
Answered "Yes" to one variable	83,072	287.81***	34.118			
Answered "Yes" to two variables	60,169	277.16***	33.744			
Student School Didactic Usage Index						
Never or hardly ever	99,971	290.05***	32.367	157,886	-	4804.000
Once every few weeks	27,426	275.03***	33.764			
About once a week	14,074	264.74***	32.672			
2 to 3 times a week	9,423	261.97***	31.848			
Every day or almost	6,993	256.16***	32.633			
Student School Constructivist Usage Index						
No, I do not use any of thse constructivist approaches	67,584	290.82***	31.195	155,172	-	5945.160
Answered "Yes" to one constructivist variable	39,736	285.44***	33.050			
Answered "Yes" to two constructivist variables	28,741	274.60***	34.609			
Answered "Yes" to all three constructivist variables	19,112	257.22***	33.821			
Teacher School Didactic: Students use computer-practice or review math						
Never or hardly ever	73,344	284.06***	34.025	148,085	-	417.902
Once/twice a month	45,613	283.16***	34.443			
Once or twice a week	21,187	276.37***	35.849			
Every day or almost	7,942	274.47***	34.890			
Teacher School Didactic:Students use computer-play math game						
Never or hardly ever	80,832	285.30***	34.037	147,999	-	797.409
Once/twice a month	49,366	280.80***	34.361			
Once or twice a week	15,486	272.50***	35.341			

Every day or almost	2,316	267.70***	36.254			
Teacher School Constructivist Usage Index						
No, I do not use any of thse constructivist approaches	64,169	282.49***	33.817	147,183	-	72.795
Answered "Yes" to one constructivist variable	40,644	280.76***	34.643			
Answered "Yes" to two constructivist variables	24,248	283.37***	35.271			
Answered "Yes" to three constructivist variables	11,029	285.68***	35.598			
Answered "Yes" to all four constructivist variables	7,094	278.60***	36.722			
Teacher Computer Competency Index						
Not at all	25,101	281.16***	34.545	148,664		21.450
Small extent	55,675	282.58***	34.279			
Moderate extent	44,783	282.62***	34.822			

* $p < .05$; ** $p < .01$; *** $p < .001$

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BIOGRAPHY

Olivia Blackmon's scope of work has been centered around STEM research in K-12, and at MSI's. Her work at Diversity in Education Fund, Education Writers Association at Harvard University, Thurgood Marshall College Fund, and World Vision has focused on individuals and groups that have been traditionally underserved by institutions, agencies, organizations and the private sector. This condition has led to these populations being underrepresented in many careers, especially positions of administration, management and influence. The outreach programs she has developed with other non-profits assist individuals that are less likely to have experienced higher levels of education and more likely to have abandoned education before they attained the diploma or degree levels necessary to success in the workplace. Most of her work has focused on global outreach, specifically targeting disadvantaged groups such as minorities, women and persons with disabilities. Additionally, she has focused her work on developing and supporting programs that eliminate barriers to opportunity and promote achievement for all regardless of their race, gender, age or ability in reading literacy and STEM fields.

Earlier in her career she was the Director of Research and Statistics for the Diversity in Education Fund and worked as the Sr. Statistical Analyst for educational related topics at the magazine Diverse: Issues In Higher Education. In 2004, she served as a research consultant for Thurgood Marshall College Fund, and in 2010 was the Director of Assessment, Evaluation and Research. Through the Thurgood Marshall College Fund, she has contributed to minority research in partnership with Innovative Educators, National Association for Equal Opportunity, National Science Foundation, The Pell Institute, Institute for International Education, and the Lumina Foundation. She was also the lead evaluator for the Southern Louis Stokes Alliance for Minority Participation (LSAMP) program. She has served as the White House liaison between U.S. public HBCUs and Brazilian universities. In 2010 she was awarded a three year grant from the Alfred P. Sloan Foundation researching the retention and migration patterns of minorities in STEM at HBCUs and TWIs. In 2012 she was a lead research consultant for World Vision International and USAID, and developed The All Children Reading Program Phase II. In addition, she developed a monitoring and evaluation framework for USAID International Reading Literacy, and was the lead technical advisor for the RFP eligibility criteria and prize competition.

Among her other experiences, Mrs. Blackmon has developed and conducted communication intelligence research for the U.S. military. Her corporate experience includes tenure with MCI Worldcom, where, among other assignments, she performed design work and quantitative analysis for federal agencies such as the FBI, CIA and various branches of the military. Mrs. Blackmon holds a TS-SCI level 12.

Her education credentials include a bachelor's degree from George Mason University in sociology and applied research and statistics. In 2007, she finished her Education Writers Association fellowship at Harvard University in Applied Statistics, focusing on minority gaps on NAEP data. In 2011, she received her Masters at George Mason University in sociology of education with a concentration in methods and applied quantitative research.