A National Study of the Relationship between Home Access to a Computer and Academic Performance Scores of Grade 12 U.S. Science Students:
An Analysis of the 2009 NAEP Data

A Dissertation

Presented to the

Graduate Faculty of the

University of Louisiana at Lafayette

In Partial Fulfillment of the

Requirements for the Degree

Doctor of Education

Mitchell Ward Coffman

Fall 2015

A National Study of the Relationship between Home Access to a Computer and Academic Performance Scores of Grade 12 U.S. Science Students:
An Analysis of the 2009 NAEP Data

Mitchell Ward Coffman

APPROVED:

Robert O. Slater, Chair
Professor of Educational Foundations and Leadership

Douglas Williams, Co-chair
Associate Professor of Curriculum and Instruction

Sharon C. Hoffman, Co-chair
Associate Professor of Educational Leadership and Technology
Southeastern Louisiana University

Mary Farmer-Kaiser
Dean of the Graduate School

Acknowledgments

To my mother and father, Mattie Lou and Vernon Dale Coffman, Sr., for your love, encouragement, support, input, feedback, and unspeakable contributions to this dissertation and my life-long pursuit of learning and education. To my siblings, Dale, Carla, and Tanya, and their spouses, Elena, Greg, and Ken, and all of their children for their continued support and patience with my scholastic endeavors and me. My sisters' willingness to support me with grace and brilliance is a blessing. Special appreciation goes to Tanya and Dr. Ken Falterman and daughter, Olivia Falterman, for their support and love. Each one of my family members has had an immeasurable influence upon me, literally saving my life in the ongoing struggle to live through and with West Nile Virus Meningoencephalitis.

Thank you to Dr. Robert Slater, committee chair and advisor, without whom this investigation would not have succeeded, nor even been pursued. Thank you for your counsel, patience, and persistence, and for introducing me to the world of peer-reviewed research and the plethora of valuable information statistics and NAEP data contributes to academia. Thank you to Dr. Douglas Williams, committee member and advisor, whose devotion to counseling, educating, and sharing the merits and joys of technology with the community and campus is both inspirational and admirable. Thanks also to Dr. Sharon Hoffman, committee member and advisor, for motivating me, and countless others to examine, question, propose, and implement educational policies, processes, and procedures with a critical eye toward embracing change that advances instruction and learning for all stakeholders. Thanks to the University of Louisiana at Lafayette's EDLD, EDFL, & IRED departments, administrations, leadership, faculty, and staff for their combined leadership. Thank you to all my classmates.

Table of Contents

List of Tables

Chapter 1: Introduction

Problem Statement

The purpose of this study was to examine what we know about the relationship between access to a computer at home and academic achievement. Are students who have access to computers at home more likely to have higher academic achievement?

The direct link between computers and academic achievement has been the focus of extensive literature and research for several decades. Studies have tried to explain the role and the benefit of the computer in classrooms and on students' academic achievement since the mainstreaming of the computer into the classroom in the late 1990s (Cuban, 1998; Mahlamud & Pop-Eleches, 2011; Wenglinsky, 1998). The initial body of literature explored the impact of computer uses upon the classroom (Angrist & Lavy, 2002; Cuban, 1998; Dahmani & Youseff, 2008). More recently, a second body of literature explored the impact of the Internet upon the classroom computer and student academic achievement (Jackson, Von Eye, Biocca, Barbatsis, Zhao, & Fitzgerald, 2006, 2011; Keller, 2009).

This dissertation investigates the impact of student computer access at home upon academic achievement. "Surprisingly, the role of home computers in the educational process has drawn very little attention in the literature" (Beltran, Das, & Fairlie, 2010, p.6; Fairlie, 2013; Fairlie & Robinson, 2013). In the United States, the federal government has made the integration of and provision of improved access to all students a mandated part of the National Educational Technology Plan incorporated into the No Child Left Behind Act (U.S. Department of Education, 2004). Home access to a computer and its impact on academic achievement is a rich area for review, especially as computer use and computer integration becomes ubiquitous in American society and business (Mahlamud & Pop-Eleches, 2011).

The Gates Foundation, founded by Microsoft Owner Bill Gates, reported that at the turn of this century, “Little research is available in this area” (Fouts, 2000 p. ii).

Consequently, this dissertation reviews the literature on the question of the relationship between students’ access to computers at home and their academic achievement. Are students who have access to computers at home more likely to have higher academic achievement? In general, what do we, as educational researchers, know about the effects of home computer use on academic performance?

By the mid-1990s, computers had revolutionized many diverse environments across the world (Cuban & Tyack, 1995). The educational field was added to this list of diverse environments by the late 1990s as a common tool of education accepted for instructional purposes (Cuban, 2009, 2010; DeSutter, 2004; Samuelson & Varian, 2001). Through this dissertation, the general awareness of students’ home access to computers and the impact that ubiquitous computing in education can have on student academic achievement will be extended to technology facilitators and policymakers for consideration.

Rationale

The question of the relationship between home access to computers and student achievement is important because current use of computers, whether at school or in the classroom and even at home, are considered to be beneficial to student academic achievement and accepted forms of instruction (Beltran, Das, & Fairlie, 2008; Cuban, 2009, 2010; Fairlie, 2013; Livingstone, 2012). Principals and teachers believe they are beneficial (Beltran et al., 2008). As such, perhaps computers used to enhance learning and information gathering in these typical educational settings might be considered as an equally important means of improving student achievement through full-time home access to a computer

(Schmitt & Wadsworth, 2004). Educational reforms, especially those related to computers and technology-based instruction, are being implemented nationally and internationally at a rapid pace (ISTE®, 2012). Integrating the computer in all of its manifestations into the educational field is a dynamic area of study especially in light of this rapidly evolving pace of computer technology (Blazer, 2008; Dias, 1999). This study will also contribute to the "body of research on the educational and societal barriers experienced by students from low-SES communities and the impact of these barriers on academic achievement" (American Psychological Association, 2015).

Perhaps the most important reason to research the relationship between home access to computers and academic achievement is the fact that the evidence for effectiveness is both limited and mixed (Livingstone, 2012; Mahlamud & Pop-Eleches, 2011; Thomas & McGee, 2012) and often-spurious (Fuchs & Woessmann, 2004a). Additionally, state standards and federal mandates, combined with performance testing, suggests that computers be linked not only to student learning but also to academic achievement (Beltran et al., 2008; Fouts, 2000; ISTE®, 2012; Wenglinsky, 1998).

Critics and even some students argue that computers, although beneficial in some instances for enhanced instruction, cannot replace the central role, and importance, of teachers with a "black box" (Megarry, 2013, Abstract). Instructors, who engaged in traditional pedagogical instructional methods, it is argued, would always be essential to student achievement (Kolikant, 2012; Oppenheimer, 1997). Critics as well as advocates of full-time computer access argue that the digital divide issue could present a firm roadblock to equal access of home computers for students of all races and an unfair challenge to minority ownership for home placement (Fairlie, 2013; Megarry, 2013; Warschauer, 2010). More recently, critics argue that computers at home entice students to engage in unproductive use of the computer, e.g., gaming and social networking (Subrahmanyam et al. 2000, 2001; Wirth & Klieme, 2003 as discussed in Fuchs & Woessman, 2004a).

These issues are of reasonable and historical consideration for families and schools, yet these concerns are fading arguments as virtual schooling, flipped classrooms, video conferencing, higher order gaming simulations, and lower manufacturing costs for computers, development of smaller computing units and smartphones, and the growing presence of widespread public and private Internet connections made available for teachers to extend learning opportunities outside of the school are expanded (Means et al., 2009; Warschauer, 2004; Warschauer & Matchuniak, 2010).

Key Terms

Access

(n) Permission to enter a channel or network or to interface with a computer or a device connected to a computer (Graves, 2009). (v) To gain entry to a channel or network or to interface with a computer or with a device attached to a computer or network. For example, when one logs onto a computer at work, home, school or in a public setting, one accesses a computer and/or network (Graves, 2009).

Computer(s)

A computer is an electronic device that manipulates information, or data. A computer has the ability to store, retrieve, and process data. Students can use a computer to type documents, send email, and browse the World Wide Web. Students can also use a computer to create spreadsheets, accounting, database management, presentations, games, and more (Baldauf, Amer, and Gower-Winter, 2014). Synonyms: personal computer, PC, laptop, netbook, ultraportable, desktop, terminal, mainframe, Internet appliance, smartphone (Google, 2014). The Census Bureau and Bureau of Labor Statistics define personal computers as desktop, laptop, netbook, notebook or tablet computers (CPS, 2012).

A computer could be understood more easily based upon the characteristics and functions of the multiple tasks, software and hardware associated (Rajarman, 2010). Computers are built to carry out a variety of instructions, e.g. add, subtract, read or write characters, compare and analyze algorithms, computer code, applications, or programs that are input correctly (Rajarman, 2010, p. 6).

Google, one of the predominant Internet search engines of the 21st Century, defines a computer as an electronic device for storing and processing data, typically in binary form, according to instructions given to the device in a program allowing for variable processing.

National School Lunch Program

NAEP collects data on student eligibility for the National School Lunch Program (NSLP) as an indicator of low income. Under the guidelines of NSLP, children from families with incomes below 130 percent of the poverty level are eligible for free meals. Those from families with incomes between 130 and 185 percent of the poverty level are eligible for reduced-price meals. For the period July 1, 2008, through June 30, 2009, for a family of four, 130 percent of the poverty level was $27,560, and 185 percent was $39,220 (NAEP, 2009 p.60).

Socioeconomic Status

Socioeconomic status (SES) is measured by determining education, income, occupation, or a composite of these dimensions (Winkleby, Jatulis, Frank, & Fortmann, 1992). In educational research, SES is a statistical control used because established data supports the notion that SES is a significant contributor to individual differences in educational outcomes (Alexander, Entwisle, & Thompson, 1987; Coleman, 1966; Mercy & Steelman, 1982; Roscigno, & Ainsworth-Darnell, 1999 as discussed in Dickinson & Adeleson, 2014).

Organization of the Review

This dissertation informs educators, teachers, school leaders, policymakers and students on the potential impact of home computer access on academic achievement. The paper is organized as follows. In the first section, the theoretical framework for undertaking the dissertation research question regarding computer access at home, for student use in education is presented. This section includes a literature review of the relationship among and between the computer and the learning theory of constructivism and the historical framing of the computer in education. The following section reviewed the literature related to the access of computers at home and any correlation to student academic achievement. This section identified and discussed common influential factors and/or variables that influenced or correlated to student academic achievement and computer access at home. This section discussed the effect of socioeconomic status (SES) factors that affect the frequency and/or type of computer use by students. Additional measures of academic performance were considered in this section, including graduation rates, discipline, and homework completion in regards to the relationship access to a computer has upon these variables. The next section reported returns from studies of state sponsored initiatives regarding computer access at home, viewed through national and international peer reviewed case studies (Spiezia, 2010). The summary of findings concludes the second portion of the dissertation.

In the third section of the paper, the research design is explained, including an overview of statistical procedures and the data source. A listing of the dependent variable, independent variable and control variables is included in this section. In Chapter Four, the results of the statistical models are reported and analyzed. The closing section of the dissertation, discusses the conclusions, implications and recommendations associated with the complete body of work presented.

Scope and Limitations

The dissertation is grounded in peer-reviewed research that investigated the relationship of and any possible effect or correlation to home access to computers has had upon academic achievement. Little research has been done in the area regarding home access (Blazer, 2008; Fairlie, 2013; Livingstone, 2012). This void of knowledge, as well as the rapid evolution of the computer in society, including types of computing devices, presents a challenge to researchers trying to maintain pace with technology and its role in educational instruction.

This dissertation does not research specific operational processes of the implementation of computers and technologies into educational settings, e.g. computer labs or classrooms (Rabalais, 2014). Discussion of teacher computer training, implementation, and professional development of computing skills is not a part of this dissertation. Additionally, this study focused upon computer access of the type families have traditionally used, i.e. desktop computers. Smartphones, portable devices, laptops, tablets, nor others, such as iPads®, are included in this study as variables nor in the NAEP dataset. This study did not address specific technology policy guidelines nor individual state or local standards. Case histories from international studies are presented as well as results from national trials and local computer access initiatives.

Extensive research exists on the influence of the Internet on academics and therefore is not a central point of research for this dissertation. A discussion of the digital divide is included as it relates to the dissertation question. Students can use software at home that may be independent of the Internet for academics. Likewise, specific software programs, learning modules, or applications may be referenced but were not a significant part of the research plan.

Library Research Plan

Numerous web-based sources, both printed and digital peer-reviewed studies, professional journal articles, dissertations, newspapers, magazines, and published books were explored to obtain literature germane to computers and the relationship to student home access and academic achievement. A robot email news service was employed to notify the author of any scholars writing on the subject of computer access and education and subsequently posted to the World Wide Web.

Academic and professional blogs, videos, and PowerPoint presentations posted online were also part of the dissertation research plan. Review of standard setting non-governmental organizations involved in computer and education policies were a part of the research, e.g., International Society for Technology in Education (ISTE®). Several editorials and articles from local and national newspapers reporting anecdotal evidence, narratives, and reviews of scholarly studies were also a part of the research.

Technology and education related commission, consortium reports, both governmental and non-governmental, were also used in the research. In addition, scholarly and peer reviewed journals were used for research. A number of reports from state educational institutions and philanthropic organizations were also explored.

Academic databases including Educational Resources Information Center (ERIC), Edutopia, Ed.gov, National Center for Educational Statistics (NCES), National Assessment of Educational Progress (NAEP), Google Scholar, and LOUIS (The Louisiana Library Network) provided access to national and international reports (Rabalais, 2014). The review contains sources from both quantitative and qualitative research.

Chapter 2: Literature Review and Conceptual Framework

The development and dissemination of information and communication technologies has had a concentrated effect on modern life and modern education (Cuban, 2001; Fairlie, 2013; Livingstone, 2013; Yu, 2008). The affordances of newer, more compact, and more powerful processing hardware, intuitive interactive user interfaces, and other developments have increased adoption of computers into society and education at an unprecedented pace (Fairlie, 2014; Megarry 2013; Warschauer & Matchuniak, 2010; Yu, 2008). The growing ubiquity of computers in society combined with an expanding presence in educational settings, especially in the homes of students could influence students in unprecedented ways. Therefore, it is prudent to ask, has access to computers at home had an impact on student academic achievement? This dissertation reviewed the literature associated with computer use in education and specifically reviewed literature that investigated any relationship student access to a computer at home may have upon academic achievement.

The limited body of research reviewed linking computers with student academic achievement over the past twenty-five years reported an association with marginally improved academic achievement (Angrist & Lavy, 2002; Beltran et al., 2008; Borsheim, Merritt, & Reed, 2008; ISTE®, 2008, 2012; Warschauer, 2010). However, the totality of the available research reviewed was mixed (Fairlie, 2013; Schmitt & Wadsworth, 2004). Some studies revealed this positive association to be small, often statistically insignificant, and at times negative in different areas of academic performance, notably academic achievement variance across subject areas (Wenglinsky, 1998). The results in the literature review are generally consistent with the research conclusions regarding the impact home access to a computer has on academic achievement. The literature reported that any impact that home access to a computer had on academic achievement was dependent upon multiple variables and characteristics associated with the student and/or study focus. A variety of household characteristics correlated with computer access and educational outcomes (Mahlamud & Pop-Eleches, 2011; Fairlie, 2013; Schmitt & Wadsworth, 2012; Warschauer, 2010; Wenglinsky, 1998). Specifically, the more influential factors that impacted student academic achievement were mostly dependent upon the students' socioeconomic status and the type of computer use engaged in while accessing a computer at home (Angrist & Lavy, 2002; Beltran et al., 2008; Blanton, Moorman, Hayes, & Warner, 1997; Clotfelter, Ladd & Vigdor, 2008; Dynarski, 2007; Fairlie, 2013; Fuchs & Woessman, 2004; Goolsbee & Guryan, 2006; Higgins, Xiao, & Katsipataki, 2012; Inan & Lowther, 2009; Li, Atkins, & Stanton, 2006; Livingstone, 2012; Mahlamud & Pop-Eleches, 2008, 2011; Rouse & Krueger, 2004; Toyama, 2011; Vigdor & Ladd, 2010; Warschauer, 2010; Warschauer & Matchuniak, 2010; Wenglinsky, 1998). In fact, once control for various household characteristics were implemented, correlations with home access to computers and educational outcomes consistently produced mixed support for the view home access was associated with improved educational achievement (Schmitt & Wadsworth, 2004). Fairlie and Robinson wrote, "There is no strong consensus in this literature on whether the effects of home computers are positive or negative" (Fairlie & Robinson, 2013, p. 2).

Theoretical Perspective

Little theoretical support exists for mandating the use of computers in education as a means to improve academic achievement (Beltran, et al., 2008; Fairlie, 2013). Alper and Gulbahar (2009) reported that only a few researchers addressed teaching theories and learning models for computer environments and any effect upon academic achievement.

They conducted research to investigate the theoretical basis of related articles published to a Jordanian national online journal from 2003-2007. Though their results were not generalizable, the authors reported that a global shortcoming in the theoretical basis for research appears to be related to the youth of the academic subject combined with the speed of technology in this area of research despite the location (Webster & Watson, 2002 as discussed in Alper & Gulbahar, 2009, p. 8). Evidence of computers having any positive benefits as a pedagogy is scattered and typically tailored or gathered from smaller studies (LeBaron & McDonough, 2009 as discussed in Livingstone, 2012, p. 10). In early research, Warschauer and Healey (1998) considered the mechanical input a model similar to the behaviorist model of Skinner (as discussed in Bataineh & Baniabdelraham, 2006, Introduction). Beetham and Sharpe hinted that Jean Piaget's learning theories and his influence on education in the form of the construction of knowledge was conducive to the implementation of the computer in education, i.e. gathering knowledge, observing, and building upon that information (Beetham & Sharpe, 2013).

Seymour Papert, protégé to Piaget and advocate for constructivist and what he termed constructionist educational pedagogy argued for a full-scale shift in instructional pedagogy toward incorporating computers into the curriculum (Papert, 1999). Papert argued that computers were likely to be the motivational instrument that led to implementation of full time constructivist education in modern society. "The computer alters the nature of the process by shifting the balance between the transfers of knowledge from instructor to the production of knowledge by students" (Papert, 1991 p. 10). In 1996, Papert reiterated his faith in computers, noting that a computer outside the control of schools would be most successful in promoting the constructivist philosophy. He expressed the necessity to integrate the computer into students' educational lifestyles as rapidly as the computer was into the American lifestyle (Papert, 1996, para. 11).

Papert wrote, "The minimal action that will make a serious difference in education is ensuring that each and every child has a personal computer, which is mostly about opening new methods of learning by having full time access to a computer" (Papert & Caperton, 1999, sec., VI).

Despite the welcome and common placement of the computer into the classroom in the 1990s, few theorists were convinced of its necessity and even fewer researchers anticipated the influence access to computers outside of the classroom could have upon instructional pedagogy and student achievement (Beltran et al., 2010; Christensen & Horn, 2008; Cuban, 1998; Oppenheimer, 1997).

Computers and Constructivism

Contemporary educational policy makers and academia emphasize constructivist instructional methods as the predominant educational theory employed to promote higher order thinking in students (Lowe, 2004; Yu, 2008). Constructivism is grounded in the belief that learning is constructed by human interactions and decisions where learners construct knowledge based on what they already understand as they make connections between new information and old information (Beetham & Sharpe, 2013; D'Angelo, et al., 2009). The connection between computer use and constructivist classroom instructional methods was well-documented in the research (Duffy & Jonassen, 1992). Strommen and Lincoln (1992) were early adopters of integrating contemporary computers into education as a constructivist tool. In 1992, the pair outlined ways to integrate computers into the traditional curriculum under constructivist pedagogy. They argued that constructivism, computers, and learning have much in common that could be the basis for a pedagogical change associated with the educational system.

Strommen and Lincoln wrote, “Embrace the future and empower our children to learn with the cultural tools they have been given. Computers, engage children with the immediacy they are used to in their everyday lives, and bends it to a new pedagogical purpose” (Strommen & Lincoln, 1992. p. 469).

Accountability

Having more access to computers has not automatically led to their greater effectiveness. Wenglinsky (1998) set the tone for measuring the effectiveness of computing in education, noting that it could be judged by whether the computer benefits students, i.e., academic achievement. Wenglinsky (2005) analyzed data of the NCES National Assessment of Education Progress (NAEP) database from 1996 for any evidence existing regarding access to computers in education, both at home and in class, to that of academic achievement. He found a negative interaction existed between computer uses in the classroom and computer use at home and test score outcomes in mathematics at both the fourth and eighth grade level, and in science at both the fourth and eighth grade level, and reading at the eighth grade level (Warschauer & Matchuniak, 2010, p. 204). In contrast, in literacy and reading achievement, 14 out of 19 International Society for Technology Education (ISTE®) studies reviewed from 2000-2008 showed strong positive effects of home computers on reading achievement (ISTE®, 2008). In science, ISTE® research revealed positive effects of the home computer on students’ science achievement assessments (Dunleavy & Heinecke, 2007; ISTE®, 2008). Other research on the influence of computer use on student achievement was reported to have many benefits for students regarding academic achievement, including improved performance scores in core subject areas (Attewell & Battle, 1991). Johnson (2000) studied the effects of accessing a computer using NAEP reading scores where he used a multiple regression to analyze the effects of the computer and other variables, such as familial income upon student achievement (Davis, 2004). Although his focus was on the quality of teacher instruction, Johnson's multiple regression model demonstrated that at least on the NAEP reading test for both fourth and eighth grades, computer access had no effect on academic achievement of students (p. 8).

Research on computers and the relationship to academic achievement and student performance remains mixed, presenting positive and negative evidence of the influence upon student learning and assessment (Cuban, 1995, 2001; Fairlie, et al. 2013; Fuchs & Woessman, 2004a; Giacquinta, Bauer, & Levin, 1993; Johnson, 2000; Mahlamud & Pop-Eleches, 2011; Oppenheimer, 2003; Ravitz, Mergendoller & Rush, 2002; Rochelle, 2000; Stoll, 1995). Importantly, these mixed results generally revealed that the degree of impact access to a home computer had upon academic achievement was determinant mostly upon societal, contextual, environmental and behavioral factors.

Fuchs and Woessman (2004a) caution that evidence on the positive relationship between computers and students' educational performance was potentially misleading because computer availability at home is correlated strongly with a myriad of other family background factors. The research reported in this dissertation consistently reported that the potential for computer access at home to improve academic achievement could be attributed to two overridingly important variables, socioeconomic status (SES) and the type of computer use engaged in by the student at home (Al-Senaidi, Lin & Poirot, 2009; Mahlamud & Pop-Eleches, 2011; Warschauer, 2010; Wenglinsky, 1998, 2008). Warschauer and

Matuchniak (2010) reported that student socioeconomic status (SES) was the strongest factor that predicted whether computer use would be positively or negatively associated with test score outcomes and academic achievement (p. 204).

Types of Computer Use and SES Correlations

Wenglinsky (2008) emphasized that the conflicting data reported in many research studies was influenced heavily by the student's type of use, especially with lower SES students. He found the more constructivist directed computer use with higher SES students was correlated with higher test score outcomes. For instance, in mathematics, Wenglinsky (2005) found that the utilization of simulations in eighth grade and the use of complex games in the fourth grade impacted test scores positively, while drill and practice exercises at the eighth grade level negatively affected scores. Again, emphasizing use, Wenglinsky concluded that the more familiar drill and practice activities favored in low SES schools tend to be ineffective, whereas the uses of computers in high SES schools that applied a more constructivist approach in computer use achieved results that were more positive (Wenglinsky, 1998, 2005). This point was consistent with Viadero's (1997) who posited that when used in tutorial or drill and skill fashion, use of the computer leads to student gains roughly equivalent to other kinds of classroom interventions such as personal tutoring. Types of computer use have also been associated directly with differing levels of socioeconomic status.

In the 2001 Programme for International Student Assessment (PISA), Mahlamud and Pop-Eleches (2008, 2011) found similar results in their analysis of the impact of vouchers provided for home computers for students living in low SES home environments. The data suggested that home access to a computer failed to show significant improvement in performance scores. Mahlamud and Pop-Eleches (2008) concluded that any negative relationship in the PISA study depended on the form of use for which the computer was accessed. Attewell and Battle (1999) used the National Longitudinal Youth Survey (NLYS88) based on standardized tests and found that without other controls, having a home computer was correlated with a 12% increase in both reading and math test scores. When SES and other factors were controlled for in their analysis, having a home computer raised test scores by a smaller 3% to 5% of the average score. Their findings suggest that students having access to a computer at home have marginally improved scores in reading and mathematics (Ben Youssef & Dahmani, 2008).

This finding was confirmed by Clotfelter et al. (2008), who reported that SES mitigated the impact having access to a home computer and the Internet had upon academic performance. Clotfelter et al. (2008) supported the results of Fuchs and Woessman (2004) finding that 5th through 8th grade students perform better on math and reading tests when there is no access to a computer at home. Clotfelter et al., (2008, p. 38) reported that the optimal rate of use is infrequent, twice a month or less and that for the average student, the introduction of home internet service did not produce additional benefits in academic achievement. They reported that students who accessed a home computer for school once or twice per month scored between four to five percent of a standard deviation higher on both reading and math assessments and students who owned a computer and did not use the computer for school, had math scores nearly indistinguishable from those without a home computer. These students, (who own a computer and do not use the computer for homework) scored slightly better in reading than those students reporting no access to a home computer (Clotfelter et al., 2008).

Scardamalia and Bereiter (2003) reported that the use of computers e.g. keyboarding, web page viewing, emailing, etc., was less engaging, a lower level of learning, i.e., non-constructivist, as Papert had originally suggested, and Wenglinsky (1998) originally reported. Warschauer (2010) argued that simple nonetheless useful skills were beneficial to academic achievements for all students, but more importantly were not an efficient model of computer use for maximizing constructive learning with computers. He suggested that computers be used to engage collaborative student centered work on real life project based situations or simulations. Warschauer (2010) noted that full time any time computer access presented students an active challenge to the material presented. This argument also parallels Papert's earliest writings regarding computers in education while confirming Wenglinsky's research into the relationship computers have upon student performance (Wenglinsky, 1998).

Beltran et al., (2010) found a relationship between home ownership of computers and high school graduation rates. They found a differential in graduation rates between computer owners and non-owners of (24) points in the NLSY97 data and (16) points in the CPS data. They noted that the (16) point difference found in the CPS data was larger than the White/Black difference (13) points in the NLSY97 data, yet the differences between and among teenagers of all races was comparable. Beltran et al., (2010) attributed the difference in computer ownership to a wide range of factors, most notably SES and type of use. Despite this, they reported an increase of (6) to (8) points in student graduation rates for those who had access to a computer at home. Fairlie (2013) reported no improvement in credits earned, improved attendance, or disciplinary actions.

Beltran et al., (2010) found that having access to a computer was associated with a slight (0.22) point positive difference in grade point average based on a four point grading scale, equal to roughly 2/3 the value of a (+) or (−) grade. They reported findings similar to earlier studies discussed that noted the influence extraneous factors had in any attempt to determine a causal relationship of computer access to academic achievement and improved performance scores. Beltran et al., (2010) noted that the use of a home computer for homework or associated schoolwork was a principal activity for those students that had access at home. They cited data from the CPS that reported 93% of U.S. public school students who had access to a computer at home used them for school assignments. Nevertheless, the Beltran et al., (2010) research confirmed earlier studies that noted the importance of extraneous factors when computer use studies attempted to determine any causal relationship of computers to academic achievement and improved student performance.

Students used home computers for many purposes (Fairlie, 2005). The most common use reported by students was to gain access to the Internet, followed by gaming, emailing, and word processing. Fairlie (2005) noted that students reported accessing a computer at home primarily to complete school assignments (p. 6). The ISTE® (International Society for Technology Education) reported that strong positive effects were seen in scores among elementary and secondary students that used computers to complete homework that reinforced the instructional objectives addressed during class (ISTE®, 2008, Policy Brief, p. 6). Mahlamud & Pop-Eleches (2011) reported that computers for home use detracted from homework completion and the computer acted as a distraction to homework for low income students.

Papanastasiou, Zemblyas, and Vrasidas (2003) found the way in which computers are used was more determinant of the positive or negative effect on academic achievement rather than SES, which they contended had a lesser effect on student outcomes (North Central Regional Educational Laboratory [NCREL], 2005). Mahlamud and Pop Eleches (2008) used the PISA results to find that computer use was negatively associated with high student achievement in some countries (CESifo, 2004; Papanastasiou et al., 2003).

More specifically, 15-year-old U.S students, based on the data from the PISA, showed that once accessed, the manner of use of the computer was associated more significantly with a positive or negative effect on performance scores (CESifo, 2004), especially in subject specific assessments. Papanastasiou et al., 2003, reported that when students' SES was controlled for, their results indicated that the students, who used computers frequently at home, including for the purpose of writing papers, tended to have higher science achievement.

Home Access Demographics

In 2000, the Kaiser Family Foundation interviewed a nationally representative sample of more than 2,000 eight to 18-year-old children enrolled in public schools and found that 74% of the students reported living in houses with computers. The percentages rose to 78% for 11 to 14-year-olds and 80% of 15 to 18-year-olds who reported computer access at home (Roberts, Foehr, & Rideout, 2005). Households with children had greater access to computers than the general population. According to CPS data cited in Warschauer & Matchuniak (2010), 70% of family households with kids under the age of 18 had computers and Internet access at home when compared to 57% of households without children (p. 183-184), suggesting children, presumably partaking in some form of necessitated access to a computer.

In fact, approximately 9 out of 10 high school students who had access to a home computer used that computer to complete school assignments (Beltran, et al., 2008; SRI, 2002). Laptop programs indicated high rates of use of the computers for homework (Mitchell Institute 2004; Urban-Lorain & Zhao, 2004). Students report that home access to a computer has allowed an amount of flexibility that is more conducive to self-directed learning, individualization, group collaboration, extended learning opportunities and increased motivation (Thomson, 2010).

Research data indicated that access to computers at home provided autonomy for students in an environment that is difficult to replicate outside of the home environment (see discussion in Dimaggio, Hargittai, Celeste, & Shafer, 2004; Fairlie & London, 2009). Beltran et al., (2010) suggested that many students used computers at school and libraries but noted home access "Represents the highest quality access in terms of availability and autonomy, which may provide the most benefits to the user" (p. 10), which paralleled Thomson's 2010 findings. Access to a home computer was reported to increase familiarity with computing skills and strengthen understanding of the material presented in the classroom, as a result arising in an increased value of computer access (Mitchell Institute, 2004; Underwood, J., Billingham, & Underwood, G., 1994).

The Pew Internet and American Life Project interviewed 700 students' parents by telephone in 2008 regarding access to computers in the home. The report showed that 89% of students ages 12 to 17 used a computer to access software and the Internet at home or any available location or time (Lenhart, Arafeh, & Smith, 2008), which confirmed the Roberts, Foehr & Rideout, 2005 study. Fairlie reported that despite the increase in access to computers at home, households without computers tend to be substantially poorer and less educated than other households (U.S. Department of Commerce 2011 as cited in Fairlie, 2013, p. 2). Robinson and Fairlie (2013) cited research from the National Telecommunications and Information Administration of 2011 that reported roughly 1 out of 4 U.S. public school students did not have access to a computer at home (Robinson & Fairlie, 2013, p. 21).

Robinson and Fairlie, wrote,, “While this gap in access to home computers seems troubling, there is no theoretical or empirical consensus on whether the home computer is a valuable input in the educational production function and whether these disparities limit academic achievement” (2013, p. 21).

Second Digital Divide

In regards to home access, the 2003 Census Population Survey (CPS) data contained statistical proof of a home use divide not categorized by race nor SES for access but by type of use by students’ (DeBell & Chapman, 2006) again confirming Wenglinsky’s earliest research (1998). Cotten, Davison, Shank and Ward indicated that white access to a computer and the Internet, (in a racially diverse mid-Atlantic school district) did not report any advantage over several other differing races and ethnicities in the study (2014). They reported the finding was true even when accounting for a number of socioeconomic and demographic background factors “that are known to affect Internet usage” (Section, Findings). Importantly, the study added to the evidence that within the United States the digital divide has become more about what the authors term “other dimensions” such as how the Internet is used, rather than merely access or ownership (Cotton, et al., 2014, section Research Implications).

Warschauer (2010) suggested that many aspects of the digital divide may be dissipating in terms of access and use amongst racial groups, “into a more dramatic divide occurring in the level of constructivist instruction provided lower SES schools” (p. 199). Warschauer (2010) referenced the 2nd divide discussed in Scardamalia and Bereiter (2003) in which they noted drill and repeat use of the computer resulted in shallow or rote learning. Attewell and Battle (1991) originally foreshadowed computer overuse for rote applications suggesting lower SES schools employed fewer computer literate teachers and were often located in low SES school districts that had schools with limited resources. Attewell (2001) considered this 2nd divide an emerging new social problem that threatened students’ learning outcomes (p. 252). Warschauer believed the 2nd divide issue to be one of great concern and expressed the need to “Deepen public understanding of this issue through a more thorough appraisal of what access to computers entails and of the ends that such access serves” (Warschauer, Conclusion, 2009).

Case Studies of Home Access Programs Increasing Achievement

Several state programs reported that student performance increased when computers were used at home, in combination with traditional instructional methods (Fouts, 2000). Personal engagement with new media and computers provided a seamless learning experience for many students especially when blended into traditional instruction (Gee, 2003, 2004; Jenkins, 2009).

North Carolina

In North Carolina, several high poverty elementary and middle schools implemented the IMPACT systemic reform program in 1995 (North Carolina Department of Public Instruction, 1995). The program provided access to computers for student use in core curricular classes, in an attempt to improve student performance scores. In the four-year study, students in high need schools enrolled in the IMPACT program demonstrated that they were 33% more likely to improve one full grade level each year in comparison to the control schools (SETDA, 2008). Student achievement was reported consistently higher in the IMPACT schools and teacher retention was reported to be 65% higher under the program. The number of college bound students also increased from 26 % to 84% over a five-year period of the program (SETDA, 2008).

Maine

In 2002, The Maine Learning Technology Initiative (MLTI) provided full time access to computer laptops for all seventh and eighth grade students. By 2009, the state expanded the program to include high schools (Stephens, 2012). Analysis of the results revealed that students with computer laptops scored higher in science, math, writing, reading, and social studies, while students who did not participate in the program scored lower in these subjects on the annual Maine Educational Assessment (MEA) statewide performance test than those with computer laptops (Lemke & Martin, 2003; Muir, Knezek, & Christensen, 2004; Silvernail & Gritter, 2007). As noted by Rockman (2004), critics of Maine's computer laptop program asserted that the $28 million per year investment was not cost efficient because the program failed to produce any results that could be interpreted as influencing student scores in an empirically significant positive outcome.

Idaho

Ravitz, Mergendoller, and Rush (2002) analyzed the Iowa Test of Basic Skills (ITBS) reading, language arts, and math scores for 31,000 Idaho students in 8th and 11th grades. They found that students who scored higher on the ITBS used computers more often at home and less often in school. Blazer (2008) suggested the ITBS results could be a result of the lack of prior computer use at home, which she considered a larger barrier to improved student performance than the lack of access to a computer at school. Ravitz, et al., (2002) reported that students' with access both at home and school, declared that their personal computer literacy capability was greater than students with access to a computer at only one location, i.e. school or home. Students with access to a computer at home and not at school self-reported their computer literacy and software knowledge as average, whereas those with access to computers only at school rated their software and computer capabilities as below average (Blazer, 2008).

Texas

In Texas, the Technology Immersion Pilot (TIP) program implemented in middle schools across the state demonstrated that discipline referrals went down by more than one-half with the addition of the computer in to one particular high school. In a separate middle school participating, 6th grade standardized math scores increased by 5%, 7th grade by 42%, and 8th grade by 24% (SETDA, 2012). Despite these positive results, the TIP program reported ultimately that student academic achievement in 22 of the TIP schools had no significant academic gains when compared to 22 similar control schools (Blazer, 2008).

Stephens (2012) acknowledged the improved standardized test scores reported in the TIP data for middle school reading students as just one of many benefits computers provided students (p.2). She relied upon and quoted Warschauer (2006, 2008), who concluded that the addition of computer technology made possible, 'Literacy processes more public, collaborative, authentic, and iterative, with greater amounts of scaffolding and feedback provided' (Warschauer, 2008, p. 64 as quoted in Stephens, 2012), which was a point emphasized by Wenglinsky, (1998, 2005) and envisioned by Papert (1991, 1996). However, in Texas, many participating schools restricted allowing computers to be taken home, which weakened the main effect, that Robinson and Fairlie (2013) said, "resulted in providing one computer for every student in the classroom, rather than to increase home access" (Endnote 5., p. 3).

Case Studies Reporting No Statistical Difference in Achievement

Michigan

In a 2006 state sponsored program, Michigan enlisted 195 schools into the Freedom to Learn (FTL) program designed to increase student academic achievement. The primary goal of the FTL program was to improve student achievement through the integration of computer technology into K-12 classrooms. Schools included elementary, middle, and high schools. 30,000 laptops were distributed to students and their teachers (L. Wilson, personal communication as reported in Argueta, Huff, Tingen, & Corn, 2011). Blazer (2008) reported that no significant differences in student performances were found between eight control schools participating in the program and eight schools abstaining from the program (p. 16). The program has also been plagued with underfunding.

Massachusetts

O'Dwyer, Russell, Bebell and Tucker-Seeley (2005) studied the relationship between 4th grade students and the use of computer technology on the English Language Arts (ELA) section of the Massachusetts Comprehensive Assessment. They reported finding no relationship between students' scores and computer access at home once SES was controlled for in the data (O'Dwyer, et al, 2005). Blazer (2008) reported that the O'Dwyer et al., 2005 study showed that those students who reported higher levels of recreational home computer use received lower performance assessment scores. They also reported no relationship between students who used their computers at home for academic activities and improved performance scores. Al Senaidi et al., (2009) noted that results from studies on this topic might indeed be mostly attributable to SES.

California

Fairlie (2013) followed with a study that provided evidence on the educational impacts of home computers by conducting a randomized control experiment with 1,123 students in grades 6-10 attending 15 schools across California, where students were provided free home computers at any level. None of the students participating in the study had a home computer before the study began. Fairlie (2013) found that even though the experiment had a large effect on computer ownership and total hours of computer use, there was no evidence of an effect on educational outcomes, including grades and standardized test scores. Fairlie

(2013) notes, “Our estimates are precise enough to rule out even moderately-sized positive or negative effects (p. 4)”.

Summary

Prior studies that examined the relationship between home computers and student academic achievement found mixed results. In one of the seminal studies regarding this, Wenglinsky found a positive association between home access to a computer in the data from the 1995 NAEP for specific subject areas, yet reported the influence as insignificant. Attewell and Battle (1999) found that test scores and grades among eighth graders were related positively to home computer use. Fairlie (2005) found a positive cross-sectional relationship between home computers and school enrollment in the 2001 Census Population Statistics (CPS). Schmitt and Wadsworth (2006) found a positive relationship between home computers and performance on the British school examinations in 1991 through 2001. Beltran et al., (2010) found a relationship between home ownership of computers and high school graduation rates.

In contrast, Fuchs and Woessman (2004a, 2004b) found a negative relationship between access to home computers and math and reading test scores in the Programme for International Student Achievement (PISA). Mahlamud and Pop-Eleches found that providing home computers to low-income children in Romania lowered academic achievement even while it improved their computer skills and cognitive ability (Mahlamud & Pop-Eleches, 2010). The conclusions drawn from this literature on the relationship between home computers and educational outcomes are limited.

The literature review of the dissertation showed a pattern consistent across much of the existing non-experimental and experimental research literature. Socioeconomic status and use were the largest determining factors that influenced the relationship between academic achievement for students with access to a computer at home (Beltran, et al., 2010; Clotfelter et al., 2008; Fuchs and Woessman, 2004; Higgins, et al., 2012; Malamahud & Pop-Eleches, 2008; Papanastasiou, et al., 2005; Warschauer, 2010; Warschauer & Matuchniak, 2010; Wenglinsky, 1998, 2005). The studies revealed that once the contextual factors were controlled for (Beltran et al., 2010; Malamahud & Pop-Eleches, 2008; Fuchs & Woessman, 2004; Wenglinsky, 1998) and socioeconomic status and students' type of use was considered (Beltran et al., 2010; Fairlie, 2005; Fuchs & Woessman, 2004; Malam0ahud & Pop- Eleches, 2008, 2011; Papanastasiou, et al., 2005.; Warschauer, 2010, 2011, 2012; Warschauer & Matuchniak, 2010; Wenglinsky, 1998, 2005) the more impact home access to a computer had upon student academic achievement. In general, computers in most areas of education were discovered to have a marginal impact on academic achievement (Ertmer & Ottenbreit-Leftwhich, 2010). Access to computers in a home does offer all students the opportunity to "Open the doors to learning" (Cuban & Kirkpatrick, 2001; Cuban & Peck, 2001 as quoted in Fairlie, 2005) and extend opportunities that support constructivist learning.

Conclusion

The literature reviewed reported that ultimately there was no direct causal link between access to a computer at home and improved academic achievement. Fuchs and Woessman (2004a) described most of the studies investigating the relationship of the computer to academic achievement as descriptive analyses that could be misinterpreted easily to show evidence of a causal relationship. However, they noted that although no direct link was found, these studies come much closer to determining a causal relationship between access to a computer at home and improved academic achievement (p.9). Fuchs and

Woessman (2004a) reported that any finding that used bivariate analysis to declare an outright causal impact of computers on student academic performance, “May well be spurious, being driven by other important factors associated with using computers at home” (Fuchs & Woessman, 2004a, p. 14).

Beltran et al., (2010) confirmed that contextual factors and associated environmental factors for both student and schools and other multiple related variables make finding a causal relationship between computers and academic performance difficult. Research in this literature review repeatedly emphasized the association of multiple factors that must be considered when researching the direct relationship to computer access and student performance (Al Senaidi, et al., 2009, p. 577). In the literature reviewed, the largest obstacles to making this connection in relation to access of a computer were SES, which typically directs the type of use (constructivist or non-constructivist) engaged in by the student, which in turn determines some degree of a positive effect or negative effect on academic achievement. Beltran et al., (2010) reported that the omission of any effects of unobserved factors, as well as observed factors could invalidate any causal interpretation of the results (p. 19).

The impact of computer use upon academic achievement has generated a great amount of interest among administrators, policymakers, parents and teachers seeking to interpret the data most valuable to student learning. Researchers agreed that measurement of the effectiveness of computers in academics and instruction can be difficult to conduct without consideration of these multiple factors or conditions associated with access, SES, types of use and a multitude of interrelated dependent conditional variables. Mixed and misinterpreted results of academic and professional studies prompt further investigation into the questions related to home computer access and academic achievement.

Fuchs and Woessman (2004a) noted,

> Our best estimates still do not necessarily show the causal effect of computers on student performance. These estimates need to be interpreted cautiously as descriptive conditional correlations, in the sense that they report the relationship between computers and student learning conditional on holding constant the other family-background and school resources (p. 9).

Chapter 3: Methodology

The purpose of this study is to investigate the following question: Do students having computer access at home demonstrate higher academic performance versus those students not having computer access at home?

Data Source

To operationalize this design and investigate the research question, data from the U.S. National Center for Education Statistics (NCES) National Assessment of Educational Progress (NAEP) of 2009 will be analyzed. NAEP administers subject assessments to U.S. students as a measure of student achievement, including queries of related issues of concern to researchers, educators, parents, and administrators. NAEP also collects background information through student questionnaires that are student reported, e.g. family and home environment (NAEP, 2014).

Research Design

This study uses a comparative-causal research or ex-post facto design (Gall et al., 2007 p.306). The purpose of this design seeks to explain occurrences through the study of cause-and-effect relationships after the action or event has taken place. In this study, the independent variable (home access to computers) is not manipulated by the researcher but is naturally occurring in the population, as is the dependent variable (academic performance). This study's results are subject to the disadvantage characteristic of this type of design, namely, inferences about causality are necessarily tentative.

Overview of Statistical Procedures

Causal-comparative research explores and tests alternative hypotheses by comparing groups of respondents. The selection of comparison groups used the extreme groups technique in order to reveal more differences within the other variable of interest (Gall, et al., 2007 p. 312).

Data analysis includes both descriptive and inferential statistical methods. The data on the categorical variables of gender, eligibility for the National School Lunch Program (NSLP), also known as the free lunch program, parental education levels, and race are presented. NAEP performance scores are summarized using descriptive statistical measures based on central tendency and dispersion including minimum, maximum, mean and standard deviation. Comparison of scores between gender categories of males and females is done using independent samples *t-test*s. Similarly, comparison of scores across categories in racial background is done using a *t-test* for each pair. Mean score is compared across eligibility status for the National School Lunch Program using the independent samples *t-test* model as is parental education level.

The major hypothesis of the study is based on comparison of mean scores among those who have a computer and those who do not have a computer at home. This is done using the independent samples *t-test* method. To include control variables of socioeconomic status (NSLP serves as proxy), parental education levels, race, and gender to assess the significance of the effect of having a computer at home on performance scores, multiple linear regression is used. As such, grade 12 science performance scores are taken as a dependent variable while the binary variable of having or not having a computer at home is taken as the predictor. The model also includes the control variables of socioeconomic status

(SES) measured by the indicator of eligibility for the NSLP or free lunch, parental education levels, race, and gender.

The conceptual model with the study predictor and all four-control variables is given as follows:

Score = $\beta 0$ + β_1Computer + β_2 Gender + β_3 Race + β_4 Socio Economic Status + β_5 Parental Education Level+ ε.

β_0 is the intercept and β_i is the regression coefficient or the slope of the line adjusting for the effect of other variables in the model. The term ε is the random error or disturbance term assumed to follow normal distribution with mean zero and constant variance σ^2. Model parameters β_i are estimated using the ordinary least squares (OLS) statistical method. In this method, the estimates of the model parameters are computed in such a way that the total squared error in the estimation process is minimized.

The goodness of the model fit is assessed using the coefficient of determination given by R square (R^2). The significance of the overall model is tested using an ANOVA F test. Significance of the individual predictor variables is done using a *t-test*. All the statistical tests are performed using a 0.05 level of significance. The analysis is performed using the National Data Explorer (NDE) online statistical analysis application used by researchers of the main NAEP database.

Sampling and Weighting

Schools and students partaking in NAEP assessments are representative of all schools nationally. NAEP reports do not provide individual scores to students or of students to schools or the public, but does “offer results for populations of students… and groups within those populations” (What NAEP does section, para 1 as discussed in Rabalais, 2014). In national-only samples, approximately 8,000 to 12,000 students are assessed per subject per grade in 400 to 650 public and private schools. For a specific subject assessment, each state sample has 2,500 to 3,000 students per grade in 100 public schools (National Assessment Governing Board, n.d.).

Results from the students are combined to provide accurate estimates of the general performance of students in the nation. Each school and student participating in the assessment represents a share of the population of interest, with the results weighted to account for the disparate representation of the selected sample. This includes oversampling of schools with higher concentrations of students from certain racial/ethnic groups and the lower sampling rates of students attending schools with fewer than 20 students. The selection procedure for schools uses stratified random sampling within categories of schools with analogous characteristics. A national sample will have a reasonable population of schools and students to yield data for U.S. public schools. This includes each of the four NAEP regions of the country, as well as for the categories and sub-groups for grade 12 science students, gender, race, eligibility in the National School Lunch Program (NSLP) and computer access at home, (NAEP, 2011).

National Data Explorer Research Analysis Models

NAEP employs several guidelines to determine statistical comparisons, which in most cases is simply the number of possible statistical tests applicable (NAEP, 2011). The NAEP National Data Explorer (NDE) uses numerous statistical measures that can be analyzed to draw inferences when comparing the average scaled scores between groups. First, NDE allows researchers to test the statistical significance between populations of interest by means of a *t*-test for independent groups (NAEP, 2008).

A *t*-test for independent samples determines a statistical difference between the two groups under examination. Groups representing a statistical difference at alpha level .05 or below are characterized as statistically significant. Groups with a statistical difference at an alpha level above .05 are not characterized as statistically significant.

Second, the NDE reports a standard error for the mean scale scores of selected populations (NAEP Standard Error, n.d.). “The standard error of measurement allows you to determine the probable range within which the individual’s true score falls” (Gall, Gall, & Borg, 2003, p. 199). According to proper distribution, accounting for a “plus or minus two standard errors of measurement” allows a researcher to forecast the mean range with 95 percent accuracy (Gall, Gall, & Borg, 2003). The standard error of measurement complements mean scale scores of student populations.

Standard errors are margins of error, and estimates based on smaller groups that are likely to have larger margins of error. To defend against the possibility that significant differences in NAEP data are not ordinary chance, error rates need to be controlled when constructing multiple simultaneous comparisons. The more comparisons that are made (e.g., comparing the performance of White, Black, Hispanic, Asian/Pacific Islander, and American Indian/Alaska Native students), the higher the probability of finding significant differences by chance. NAEP uses the Benjamini-Hochberg False Discovery Rate (FDR) method for control of the anticipated proportion of falsely rejected hypotheses relative to the quantity of comparisons run (NCES, 2011).

Additionally, the NDE uses an online statistical module that permits linear regression analysis to be run actively on the variable sets. Literature review research also used multiple regression analysis to manipulate data. Regression is useful to determine the relationship between an independent variable and a dependent variable; multiple regression examines this relationship with multiple independent, or predictor, variables. This technique enables researchers to determine the relative impact of each variable on the dependent, or criterion variable (Cohen & Cohen, 1975). A multiple regression equation can be created in the NDE with this information to predict the value of an unknown criterion variable.

The current research proposes a multiple regression analysis to understand the impact of demographic variables on academic performance. When the factors for each set of variables are identified, a linear regression model will determine if a significant relationship existed between students and family socioeconomic status (SES), parental education levels, race, and gender as it relates to access of a computer at home and resulting academic performance scores. Using the 2009 NAEP, a researcher can analyze the national sample and the NAEP reported sub-groups of proxies for socioeconomic status (SES), parental education levels, race, and gender.

By establishing the relations of eligibility for free or reduced-lunch, parental education levels, race, and gender on achievement of students in public schools, one can attempt to determine the differential impact of these predictors on the main research question under study. If the null hypothesis is rejected and a significant relationship is found, effect sizes are calculated to discuss the bearing on findings. The effect size quantifies the impact of the independent variable.

Variables in the Study

Using the Main NAEP Data Explorer (NDE), the following specific jurisdictions, populations, variables, and representative questions were included in the 2009 NAEP data set for grade 12 general science assessment of U.S. public school students (see Table 1 for definitions and measures).

Dependent Variable

Variable: NAEP Science Scale Overall [ID: SRPUV] Jurisdiction: National public. Year: 2009. The NAEP science scale score ranges from 0 to 300. The NAEP Science assessment measures students across three broad areas including Physical Science, Life Science, Earth and Space Sciences. Conceptual understanding is the primary focus of the test; other assessment items include "paper-and-pencil questions, hands on performance tasks, and interactive computer tasks" (NAEP, 2012c, Comparison Frameworks section as discussed in Rabalais, 2014).

Independent Variable

Variable: Computer at home [ID: B017101] Full Title: Is there a computer at home that you use? (student-reported) Values: Yes, No. Research considers an alternative environment to accessing a computer for schoolwork, i.e. at home, an opportunity to provide an environment more conducive to learning with a computer for academic achievement (Cuban, 2001; Fairlie, 2013; Warschauer, 2010).

Control Variables

The following control variables will be featured in this study: Variable: National School Lunch Program eligibility [ID: SLUNCH3] Full Title: Student eligibility for National School Lunch Program based on school records. Values: Eligible, Not Eligible. For this study, a student's eligibility for the National School Lunch Program (NSLP) can be used to represent a student's SES status.

Socioeconomic status is one of the most widely used variables in education research when studying student academic achievement (Sirin, 2005). A link between families' socioeconomic levels and student academic performance has been established (Valadez & Duran, 2007).

Variable: Parental Education Levels Full Title: Parental education: [ID: PARED] Highest level achieved by either parent (based on student responses to two background questions).

Variable: Race/ethnicity allowing multiple responses, school-reported [ID: SDRACE] Full Title: Race/ethnicity based on student responses to two background questions with an option to choose more than one race data for Asian and Native

Hawaiian/Other Pacific Islander categories are combined; variable not used in NAEP reporting. Values: White, Black, Hispanic.

Variable: Gender: [ID: GENDER] Full Title: Gender of student as taken from school records. Values: Male, Female.

Research in the area of computer access at home cited studies in which computer access at home has widened the achievement gap of students from differing socioeconomic levels (Megarry, 2013; Vigdor & Ladd, 2010). The literature review detailed several difficulties of evaluating current and past programs that concentrated upon student computer access from home, specifically distorted results for those students and families of a low socioeconomic status (SES), (Mahlamud & Pop-Eleches, 2011; Reynolds, 2013).

Accordingly, demographic variables will be isolated and controlled to create subgroups for comparison. Research surveys conducted by the NCES indicate that race continues to be a critical factor when studying student academic achievement in the United States in the context of SES (Sirin, 2005).

Finally, an analysis will be conducted to report if increased computer access at home better serves these students' academic performance scores. Robust sampling of NAEP participants across physical and social demography will support generalizing the findings.

Chapter 4: Data Analysis and Discussion

Science Scores and At-home Computer Access

The central question of this research is whether there is a relationship between the access of a computer at home and 12th grade science scores. Do students who report having access to a computer at home tend to have higher science scores than those who report not having a computer at home?

Table 2 shows the average 12th grade science scores for both groups of students: those having a computer at home and those who do not. From the table we can see that the average score for students having a computer is 151 while the score for students not having a computer is 127, (151-127) a difference of 24 points and one that, taking into account the standard errors, is statistically significant. This data finding implies, therefore, that there is a relationship between science scores and at-home computer access.

As suggested in the literature review, the relationship that we see in Table 2 between science scores and home access to a computer may be a result of the correlation of at-home computer access with socioeconomic status. It is likely that students who have access to a computer at home are from families who are wealthier than those of students who report not having a computer at home. We know that there is a relationship between socioeconomic status and test scores (Johnson, 2000). Accordingly, perhaps the relationship we see in Table 2 is the result of a correlation between at-home computer access and socioeconomic status. In other words, were it not for socioeconomic status, there would be no relationship between computers at home and science scores. If this is the case, we need to control for SES and when we do we should see the 24-point difference shown in Table 2 either reduced or eliminated.

In so doing, Table 3 shows the relationship between having a computer at home and science scores for students in different socioeconomic groups. From the table we can see that even when we control for SES there is still a gap in science scores for those students who have computers at home and those who do not. This gap is bigger for wealthier students than it is for poor students. Among those students not eligible for the free and reduced lunch program there is about a 25-point gap (157-132), similar in size to the one we found in Table 2. Among the students eligible for free and reduced lunch, however, the gap is only 11 points (134-123).

The data presented suggests having a computer in the home does seem to make a difference for science scores for both the wealthier students and lower income students, although the difference seems to be larger for those students who are not eligible for the free and reduced lunch program, i.e. wealthier students.

Achievement gaps exist between those students eligible for free or reduced price lunch and those who are not as it relates to who has access to a home computer and who does not have access to a home computer, 11 points, as well as for those students not eligible who have home access and those students who do not, 25 points. Interestingly, the gaps differ between the poorer students who have home access and the poorer students who do not, 11 points. Why do computers seem to make less of a difference for science achievement for poorer students than they do for the wealthier students? Could this be evidence of the second digital divide?

Perhaps access to computers is not able to compensate for the deficits that poor students have to deal with whereas once those deficits are eliminated, the effects of computers are stronger. In other words, computers make a difference but they cannot make all the difference. One could reasonably assert that poorer students, and disadvantaged classes face more obstacles to learning than those of wealthier students and advantaged classes encounter. In view of that, the data presented suggests computer access cannot overcome all the obstacles presented to the poorer student.

One way we might further explore the impact of computer access at home upon these classes of students, i.e. wealthy vs. lower income SES groups would be to analyze the scores of students' controlling for student parental education levels in those SES groups. We know that socioeconomic status (SES) can be measured as a combination of education, income and occupation (American Psychological Association [APA], 2015). Theoretically speaking, students whose parents graduated college instill a stronger sense of scholastic discipline in their children while encouraging academics as a means to career success, where in turn access to a computer at home is more likely a common occurrence. Table 4 tests this hypothesis by analyzing the scores of students with and without access to a computer at home based upon parental education.

From the table, we can see that those students with computer access whose parents did not graduate from high school (133) scored 6-points lesser than those students with access whose parents graduated high school (139). The small point gain is statistically significant, yet nearly the same numerical 4-point difference as the same groups of students within the same categories of education levels who do not have access to a computer at home (121-125), see Table 4. This finding may show that students with access and low educated parents with access, computer access makes relatively no benefit for either. In Table 4, we see a 22-point gap for those students who have access to a computer and whose parents have graduated high school compared to those students who have access and parents have graduated college (139-161), similar to the 24-point gap reported in Table 2. Those students without access to a computer, whose parents did not finish high school, reported a 12-point deficit compared to students without access to a computer and whose parents graduated college, (125-137). This finding is similar to the 11-point difference reported in Table 3 for low SES students with and without access, further suggesting the struggles of poverty effect scores when parental education is at lower levels. To investigate this hypothesis further, we can look at the variables of SES and parental education in tandem for evidence that may present additional information in the developing trend presented thus far.

From Table 5 we can see that even when we control for SES and parental education levels there is still a gap in science scores for those NSLP eligible students who have computers at home and those who do not. This gap is smaller for low SES students having more educated parents than it is for the same students having less educated parents. Among this group of students with parents that graduated college, with and without access, there is about a 10-point gap (137-127). Among the students with access or not and parents not having graduated high school, the gap is 12 points (132-120), though not statistically significant considering the standard error statistics. This result again suggests that the challenges confronting poorer students of less educated families as it relates to higher academic achievement supersede any beneficial effects of home access to a computer. In fact, the finding in Table 5 of the 10-point gap and 12-point gap is nearly the same as the 11-point gap found in Table 3. This finding confirms earlier research indicating that academic skills are correlated with the home environment, where low literacy environments or lack of family education was reported to negatively affect children's academic abilities (Morgan, Farkas, Hillemeier, & Maczuga, 2009 as discussed in APA Education and Socioeconomic Status, 2015). The finding in Table 5 shows that lower SES standing affects students' academic progress negatively (Aikens & Barbarin, 2008 as discussed in APA Education and Socioeconomic Status, 2015). However, the data is unclear for wealthier students as reflected in Table 5; students not eligible for NSLP do not meet NAEP reporting standards, perhaps because these wealthier students already all have computers at home.

From the data presented to this point, it appears as though a pattern is developing when looking at the effect home access to a computer has upon academic achievement vis a vis NAEP performance scores. That is, access to a computer at home makes a statistical difference in bivariate analysis, however once control variables are entertained, the difference in performance scores shows little relative change to the national average and the averages of those with and without access. In other words, computer access at home does not suppress the environmental and contextual challenges facing students allowing them to score higher on science performance tests, nor benefit significantly students of higher income and educated families to any greater degree. As noted by Johnson (2000), this result does not suggest that poor families have children who perform worse than wealthier families' students on the NAEP because they are poor, rather poor families may have unobservable characteristics or challenges that make it more difficult to succeed in school (p. 5). Pursuing this narrative and statistical trend further, we could analyze academic performance to ascertain the degree of influence home access to a computer has upon students' scores of different races. Does the relationship between student computer access at home and student science scores differ for different races?

Table 6 shows the relationship between having a computer at home and science scores for students categorized by race. From the table we can see that even when controlling for race there is still a gap in performance scores for those students who have access to a computer at home and those without access. The 22-point gap (160-138) is larger for Whites than Blacks and larger than any other race; similar in size to the statistical result reported in Table 2. Among Black students with and without access, the achievement gap is only 13-points (126-113), similar to finding in Table 3 and Table 4, and among Hispanic students the achievement gap is 14-points (135-121), also similar to the findings in Table 3 and Table 4. These findings further augment the proffered hypothesis (developed in the unfolding statistical construct) suggesting that disadvantaged students cannot overcome social, contextual and environmental challenges faced in their educational lives to improve performance scores through access to a computer at home. As advised by Johnson (2000), "The categories of Black and Hispanic students (may) cover children whose characteristics other than their race may make it more difficult for them to score well" (p. 5).

Having noted that home access to a computer as it relates to SES and parental education and race have little varying effect upon academic achievement, we now turn to the question regarding the effects of home access to a computer on academic performance as it relates to gender. Specifically, asking does the relationship between computer access at home and science scores differ for males and females?

Table 7 shows that the gap between those who have access to computers at home and those who do not exists for males and females. Males who have access to a computer at home report a 26 point advantage in scores over males who lack access to a computer at home (154-128), similar to the finding in Table 2 of a 24 point advantage for those who have access. Females report a 23 point gap for those who have access and those who do not (125-148), again similar to the 24 point finding referenced in Table 2. Additionally, Males with and without access to a computer at home, show little advantage over the same categories of females. Males with access score 6 points better than females of the same group (154-148) while males without access score 3 points better than females (128-125). Both males and females with and without access report similar average scale scores as seen in Table 2 for those with and without access. Computer access as an issue appears to have little influence upon the overall scores broken down by gender, at least in comparison to the overall national average science scores broken down by males and females, as seen Table B6, and mimics the gaps seen for the question regarding access reported in Table 2.

The data reported to this point reveals a pattern. Computer access at home is a significant statistical element in relation to academic performance scores, yet factors including contextual, educational, financial, and racial groups typically associated with poverty, fail to benefit to any great extent, from access to a computer at home as compared to the national average scores of each category of students and groups referenced, see Tables B3-B6. These scores do not vary greatly from the 24-point results seen in Table 2 regarding the question of access. In the following sections, an analysis of the data, including significance analyses and regression models are presented supporting the trend outlined in the preceding text.

Further Testing the Effect of Access to a Computer at Home on Academic Performance

The null hypothesis states that there is no relationship between student access to a computer at home and academic performance scores. Table 2 reports the summary of the test for the difference in academic performance between those who have access and those who do not have access to a computer at home. Those who have access report a mean score of (M = 151), (S = 0.9). Students who do not have access to a computer at home report a mean score of (M = 127), (S = 2.2). Students who have access to a computer at home report higher mean scores. The results for the student's *t-test* for independent samples indicate that the null hypothesis of no significant difference in mean scores can be rejected at the 0.05 level of significance ($p < .001$), see Table A2. The 2009 NAEP average scale scores of all national public grade 12 science students has a reported mean of (M =149), (S = 0.9), see Table A1.

The results of Table A2 indicate there is a significant difference in mean scores between students who have access and those who do not have access to a computer at home. More precisely, students who have access to a computer at home report significantly higher mean scores compared to those who do not have access to a computer at home. Access to a computer at home reports significant positive effects on academic performance.

However as presented in the literature and the narrative of this dissertation, perhaps this difference is a result of socioeconomic differences. As discussed, it is likely the case that the students who do not have access to computers at home are also from high poverty families and, therefore, their differences in achievement are the results of other factors associated with poverty and not simply because they do not have access to a computer at home.

Further Testing the Effect of SES on Academic Performance

Is there a significant relationship between a student's SES and access to a computer at home and academic performance scores? The null hypothesis states that there is no significant relationship between a student's SES and academic performance scores for those with access to a computer at home and those without access.

Table 3 reports the summary of the test for the difference in academic performance between students with access to a computer at home who are eligible and those not eligible for the NSLP or free lunch program. Students with access to a computer at home who are eligible for the free lunch program report a mean score of (M = 134), (S = 1.0). Those with access to a computer at home who are not eligible for the free lunch program report a mean score of (M = 157), (S = 0.8). Students with access to a computer at home who are not eligible for the school lunch program report higher mean performance scores. Results of the student's *t-test* for independent samples indicate that the null hypothesis of no significant difference in mean scores can be rejected at a 0.05 level of significance (p <.001), see Table A3. For reference Table B3 reports the 2009 NAEP average scale scores of all national public grade 12 science students reported by NSLP eligibility as (M = 156), (S = 0.9) for those not eligible and (M = 132), (S = 1.0), a statistically significant difference (p <.001).

This finding can be interpreted as reporting that there is a significant difference in mean scores between students with access to a computer at home who are eligible and those with access to a computer at home who are not eligible for the free school lunch program. More precisely, students with access to a computer at home who are not eligible for the school lunch program (higher SES) outperform significantly those with access to a computer at home who are eligible for the free lunch program (lower SES). Results indicated that socioeconomic status significantly influences the academic performance of students with access to a computer at home, noting that access does not override the cumulative effects of poverty. As noted, Table 3 tests for this possibility by examining the relationship between computer access and achievement for students with different levels of SES.

Table A3 tests also for this possibility by examining the relationship between computer access and achievement for students with different levels of SES in a cross tabulation format. The difference from both those who have access and those who do not have access as well as within each category is reported. Those students eligible for NSLP with access to a computer at home score an average of 10 points higher than those students eligible without access to a computer at home, showing significance for those with access to a computer ($p = 0.0001$). Additionally, those students not eligible for NSLP (a higher SES) without access to a computer report no significant difference ($p = 0.6478$) in scores, 2 points, compared to those students who are eligible (a lower SES) with access to a computer at home. In other words, higher SES students without a computer score on average 2 points higher mean scores over the lower SES students with access to a computer, a non-significant finding suggesting little influence arising from access for the two groups.

Further Testing the Effect of Parental Education Levels on Academic Performance

Is there a significant relationship between student parental education levels and access to a computer at home and academic performance scores? The null hypothesis states that there is no significant relationship between student parental education levels and academic performance scores for those students with access to a computer at home.

Table 4 reports the summary of the tests for the difference in academic performance scores across parental education levels for students with and without access to computers at home. Students with access to a computer at home and whose parents did not graduate high school report a mean score of (M = 139) while students whose parents did graduate high school and have access to a computer at home report a mean score of (M = 125), similar to the 11-point gap seen in Table 3 for poorer students. In Table 5, we clearly see the trend continue in the 12-point gap in scores (132-120) for the least educated families-those who did not finish high school and have access as well as those who did not finish high school and do not have access. This result is nearly the same as the 11-point gap seen in Table 3 for the lowest of SES categories (134-123) and in the 12-point gap seen in Table 4 for the least educated categories (133-121). Table A4 presents the results in cross tabulation format. The combination of these two results strongly suggests that the most disadvantaged students appear not to benefit significantly from access to a computer at home.

Further Testing the Effect of Race on Academic Performance

Is there a significant relationship between student race and access to a computer at home and academic performance scores? The null hypothesis states that there is no significant relationship between student race and academic performance scores for those students with access to a computer at home.

Table 6 reports the summary of tests for the difference in academic performance across racial backgrounds for students with access to a computer at home. Whites report a mean score of (M = 160) while students of Black race report a mean score of (M = 126), the largest of gaps, 34-points of any of the races. Table 6 shows that Blacks and Hispanics follow the trend for disadvantaged groups, with a 13-point gap reported for Blacks as it relates to access (126-113) while Hispanics report a 14-point gap between those with access and those without (135-121). These findings are similar to the findings in Table 3 and Table 4 that appear to show little advantage for these students by having access to a computer at home. Asian and/or Pacific Islanders report a mean score of (M = 165) while the students belonging to American Indian or Native Alaska background do not meet reporting standards. Statistical tests for pair wise comparisons were performed after adjusting for the inflation of type I error probability by using the false discovery rate procedure.

Students with access to a computer at home belonging to White and Asian/Pacific Islander background report no significant difference ($p = 0.17$), see Table A5. However, these same groups of Whites and Asian/Pacific Islanders report significantly higher mean scores compared to other race categories of Black, Hispanic and American Indians.

Students with access to a computer at home belonging to Black race report significantly lesser mean scores compared to all other races, further highlighting the achievement gap for disadvantage populations and the secondary role access to a computer at home may take to poverty in relation to improved academic performance scores. Similarly, Hispanics with access to a computer at home report significantly higher mean scores than

Blacks but lesser mean scores compared to other races. Summary of these results signifies that Whites and Asians/Pacific Islanders form the first homogenous group with the highest academic performance followed by Hispanics, with students belonging to Black race reporting the lowest academic performance. These findings are similar to NAEP reporting that "At grade 12, there was no significant difference in scores for White and Asian/Pacific Islander students, and both groups scored higher on average than other racial/ethnic groups" (NAEP Science Executive Summary, 2009).

For reference, the 2009 NAEP average scale scores of all national public grade 12 science students reported by race are presented in Table B5, reflecting little difference in the scores reported in Table 6 regarding the question of access. As seen in Table B5, reported averages scores for Whites were (M = 159), S = (0.7); Black (M = 124), (S = 1.3); Hispanic (M = 133), (S = 1.2); Asian/Pacific Islander (M = 164), (S = 3.3); American Indian/Alaska Native (M = 144), (S = 3.7).

Further Testing the Effect of Gender on Academic Performance

Is there a significant relationship between student gender with access to a computer at home and academic performance scores? The null hypothesis states that there is no significant relationship between student gender with access to a computer at home and academic performance scores.

Table 7 reports the summary of tests for the difference in academic performance scores between male and female students with and without access to a computer at home. Male students report a mean score of (M = 154), S = (0.9). Female students report a mean score of (M = 148), (S = 1.0). Male students with access report higher mean scores. Table A6 reports results of the student's *t-test* for independent samples that indicate that the null hypothesis of no significant difference in mean scores can be rejected at 0.05 level of significance ($p < .001$). This means that there is a significant difference in mean scores between male and female students. More precisely, male students significantly outperform female students. Gender reports a significant effect on academic performance. In comparison, Table B6 reports the 2009 NAEP average scale scores of all national public grade 12 science students also has a reported mean of ($M = 152$), ($S = 1.0$) for males and a mean of ($M = 146$), ($S = 1.0$) for females, a statistically significant difference ($p < .001$). The statistical test results are equal to the overall average mean score of all males and females in grade 12 science, see Table B6 where males report ($M = 152$) and females report a ($M = 146$), suggesting computer access at home is not an overriding factor in scores based upon gender.

Further Testing the Effect on Access to a Computer at Home on Academic Performance Adjusting for the Effect of Gender, Race and Socioeconomic Status

Is there a significant relationship between student access to a computer at home and academic performance scores after adjusting for the effect of gender, race and socioeconomic status (SES)? The null hypothesis states that there is no relationship between student access to a computer at home and academic performance scores after adjusting for the effect of gender, race and socioeconomic status (SES).

A multiple regression model was fitted using the Ordinary Least Squares (OLS) method of estimation. This was done in two versions taking three predictor variables at a time. This model was used as the NDE online analysis tool allowed only three predictor variables to be analyzed at a time. In this study computer access was the predictor variable of interest. Three control variables being added to the model would make the number of variables four, which is not allowed in the data analysis reports generated by NDE online analysis. In the first model, see Table 8 computer access along with gender and SES control variables were taken as independent variables in the model. In the second model, see Table 10, computer access along with gender and race were included in the model.

Table 9 reports the summary of model parameter estimates and test for the significance for the first model where computer access along with control variables of gender and lunch program eligibility (SES) are used as independent variables in the model. As seen in Table 8, the fitted model reports an R square value of 0.11 (R^2 = 0.11), which means that 11.0% of total variability in score is accounted for by computer access, gender and school lunch program eligibility status. Alternatively, 89% of the total variability in scores is attributable to other factors besides the ones in the treatment. R^2 is a descriptive statistic quantifying the strength of the relationship between groups and the variable measured (Frost, 2014).

Table 8 reports the results of the ANOVA F test that indicated the overall fitted model is statistically significant (F (4, 2148.66) = 69.45, p = <.000). If the null hypothesis were true, one would expect the F statistic to have a value close to 1.0. This resulting large F ratio signifies that the variation among group means is more than one would expect to see by chance (Zar, 2009). A larger F ratio generally signifies a rejection of the null hypothesis. This means that at least one predictor variable is statistically significant.

Table 10 tests significance in the second model, whereby computer access along with control variables of gender and race were used as independent variables in the model. Male was taken as the reference category for the gender dummy variable predictor while Whites in the category of race was taken as a reference category for the categorical control variable race. The fitted model reports an R square value of 0.18, (R^2 = 0.18) which means that 18.0% of total variability in performance scores is accounted for by computer access, gender and the race of the student. Alternatively, 82% of variability in performance scores is attributable to other factors.

The results of the ANOVA F test indicated that the overall fitted model is statistically significant (F (8, 4142.64) = 115.07, p = <.001). This means that at least one predictor variable was found statistically significant.

Table 11 reports the summary for model two, showing the estimated coefficient for the computer access is (b = -16.39). The computer access variable was included in the regression model as a dummy variable with those having access to a computer at home taken as a reference category. The estimate of the model parameter for computer access binary predictor b = (-16.39), meaning that adjusting for the effect of gender and school lunch program eligibility, grade 12 science students not having access to a computer at home report 16.39 lesser points compared to those grade 12 science students who have access to a computer at home.

The results of the test for the significance of this estimated coefficient indicated that the null hypothesis of no significant effect of computer access at home upon students' performance can be rejected at the .05 level of significance (t (4142.64) = 7.9824, p = <.001). This means that adjusting for the effect of gender and race of students, computer access at home has a significant effect on academic performance. More precisely, the model reports a significant positive effect on academic performance adjusting for the effect of gender and race of students.

In model one, the estimated coefficient for computer access at home is b = -16.46. The computer access variable is included in the regression model as a dummy variable with those having access to a computer at home taken as a reference category. The estimate of the model parameter for computer access binary predictor b = -16.46, which means that adjusting for the effect of gender and school lunch program eligibility, students not having access to a computer at home report 16.46 mean score (M = 16.46) lesser compared to those who have access to a computer at home.

Results of the test for the significance of this estimated coefficient indicated that the null hypothesis of no significant effect of computer access at home on performance scores of grade 12 science students can be rejected at the 0.05 level of significance (t (2148.66) = 7.37, p = <.001), see Table 8 and Table 9. This means that adjusting for the effect of gender and the free lunch program eligibility, computer access reports significant effects on the academic performance of grade 12 science students. More precisely, the model reports a significant positive effect on academic performance.

Discussion

The body of research reviewed linking computers with student academic achievement over the past twenty-five years reported an association with marginally improved academic achievement (Angrist & Lavy, 2002; Beltran et al., 2008; Borsheim, Merritt, & Reed, 2008; ISTE®, 2008, 2012; Warschauer, 2010). This study used computer access as a predictor of academic performance for grade 12 Science students. Results of the analysis clearly indicate that computer access improves the academic performance. When no control variables are included, a large and statistically significant difference in mean scores was reported (M = 24). This mean score varies little even after controlling for variables, and stays near the 24-point gap for all variables having computer access at home.

When the control variables of gender, race and SES status were used as in the regression models, results indicated a small reduction in the mean score. The difference in mean scores between those who had access to a computer at home and those who did not have access to a computer at home was 8 points compared to the 24-point finding in Table 2. However, the direction nor the statistical significance changed. Even, adjusting for the effect of gender, race and SES status, it was found that students who had access to a computer at home, reported a mean score of 16 points, (M = 16) higher than those who did not have access to a computer at home and this difference was found to be statistically significant.

These results are consistent generally with results reported by several studies in the past (Angrist & Lavy, 2002; Beltran et al., 2008; Fairlie, 2013; Fuchs & Woessmann, 2004; ISTE®, 2008, 2012; Mahlamud & Pop-Eleches, 2011; Merritt, & Reed, 2008; Warschauer, 2010) in that significant differences can be found in bivariate analyses. However, the coefficient of determination reported by the effect of predictor variables upon academic performance, which is generally taken as a measure of the effect size, is reported as moderate to low, both historically and in this dissertation. Vigdor, Ladd and Martinez (2014), found modestly sized negative effects of home computer access on math and reading test scores when including fixed effects. In contrast, they found positive estimates when student fixed effects were excluded. Beltran, et al., (2010) found that adding student fixed effects results in smaller positive point estimates that lose significance (Fairlie & Bulman, 2015).

Reviewing the two models, the first ANOVA model controlling for gender and SES reported a higher degree of variability than did the second ANOVA model controlling for gender and race, ($R^2 = 0.11$) and ($R^2 = 0.18$) respectively. The coefficient of determination is not large for either models. This statistic is interpreted as a measure of the effect size reported by the inclusion of predictor variables. This in summary means a statistically significant improvement in performance scores for those having access to a computer at home, adjusting for the effect of gender, race and SES status can be found 16 points with SES and race presenting the greater influence of the controls.

The magnitude of improvement may not be large when potentially unaccounted for controls are added to the model. In the models presented, race presents more of a trending influential correlation than does SES and gender. This finding may be related to the statistical methods and ANOVA models (Model 1 and Model 2) employed by this current study and the associated limitations with the NDE online analysis tool. The finding is in line with the literature review that detailed several current and past programs that concentrated upon student computer access from home, often producing distorted results for those students and families of a low socioeconomic status (SES), (Mahlamud & Pop-Eleches, 2011; Reynolds, 2013).

Chapter 5: Summary, Conclusions and Recommendations

Summary

The purpose of this study was to investigate the following question: Do students with access to a computer at home demonstrate higher academic performance versus those students not having computer access at home?

In this study, a correlation was found when controlling for the demographic factors of socioeconomic status (SES), parental education, race, and gender. Among all groups and categories, students with access to a computer at home had the highest science performance scores, those with the wealthier and more educated parents benefitting the most. As such, SES was influential on score outcomes, revealing that poorer students-eligible for NSLP and/or offspring of the least educated parents-did not benefit from having access to a computer at home as much as wealthier students. The following bullets summarize the main findings.

Upon examination of the 2009 NAEP science assessments, all null hypotheses were rejected, as significant differences in performance scores were reported. Based on analysis of national science performance scores, findings included:

- Students with access to a computer at home outperformed students without access to a computer at home (151-127). In other words, there is a 24-point gap between those who have access and those who do not, see Table 2.
- When controlling for SES the effects of computer access at home on science scores of poor students are about half what they are for the wealthier students, (11 vs. 25 points), see Table 3. In other words, the initial 24-point gap

between access and no access remains for the wealthier students but is reduced for the poorer students.

- This same pattern persists when controlling for parental education levels. There is a 24-point gap for those who have access and those who do not among the students with highly educated parents. However, among those students with less educated parents, the gap between those who have access and those who do not is smaller; 12 points see Table 4.
- The pattern persists as well when controlling for race. The impact for computer access at home is greater for White students with access to a computer at home than it is for Black and Hispanic students see Table 6.
- The effect of computer access does not however appear to be influenced by gender. The gap between males who have access and do not have access is about 26 points and for females the gap is about 23 points, see Table 7.
- The regression equation, see Tables 8-11, affirms the pattern seen in the tables. Gender has little effect on the relationship while race, wealth and parental education do have an effect and make a difference on science scores.

Conclusions

Having access to a computer at home does seem to make a positive difference for science scores, but it appears to make less of a difference in science scores for poorer students, Blacks, Hispanics, and students with parents having low education. Science scores of wealthier students, White students, and students with parents having a college education, with access to a computer at home tend on average to score 24 points higher than students with similar demographics that do not have access at home. For these advantaged students, access to a computer seems to have twice the impact it has upon scores as it does for poorer students. The effects of having access for poor Blacks and Hispanics, and for students with parents having little education appear to be about half the effect of that for advantaged students, being roughly 11 points. Poverty and its correlates appear to overrule or override somewhat, any salutary benefit of home access to a computer. The achievement gap results reported may be evidence of the second digital divide reported in the literature review.

On its face, these findings are encouraging for students, education technology specialists and computing companies. In contemporary educational settings, those using computers have some advantages (Kmitta & Davis, 2004). Nonetheless, as the literature review cautioned, making a causal connection between home access of a computer and increased academic achievement could be ill advised because of the many different variables that surround a student's ability to access a home computer. Including additional variables, e.g. type of use (Beltran et al., 2010; Wenglinsky, 2005), time spent using (Wenglinsky, 1998), and even the number of computers in the house (Mahlamud & Pop-Eleches, 2011) could alter the resulting significance of a statistical analysis seeking causation and/or correlation.

Recommendations

Those interested in the effects that having access to a home computer has upon academic performance scores might broaden a similar investigation to include alternate control variables contained in the 2009 NAEP science assessment data. By broadening the analysis, one might be able to determine if the poverty effect and achievement gap or the second digital divide described reported herein is overcome by some single condition or combination of such resulting in an overwhelmingly beneficial effect of having home access to a computer. Further research, may provide insight into the persistence of the achievement gap between the wealthy and the disadvantaged.

References

Al-Senaidi, S., Lin, L., & Poirot, J. (2009). Barriers to adopting technology for teaching and learning in Oman. *Computers & Education*, *53*(3), 575-590.

Alper, A., & Gulbahar, Y. (2009). Trends and Issues in Educational Technologies: A review of recent research in TOJET. *The Turkish Online Journal of Educational Technology-TOJET, 2(8), 12.* Retrieved from http://files.eric.ed.gov/fulltext/ED505942.pdf.

American Psychological Association (2015). Education and socioeconomic status. Retrieved from http://www.apa.org/pi/ses/resources/publications/factsheet-education.aspx.

Angrist, J., Lavy, V., & Schlosser, A. (2010). Multiple experiments for the causal link between the quantity and quality of children. *Journal of Labor Economics*, *28*(4), 773-824.

Argueta, R., Huff, D. J., Tingen, J., & Corn, J. O. (2011). Laptop initiatives: Summary of research across six states. *Friday Institute for Educational Innovation*, North Carolina State University. Raleigh, NC. Retrieved from http://designs.wmwikis.net/file/view/1-1+Initiative+Henrico+County.pdf

Attewell, P. & Battle, J. (1999). Home computers and school performance. *Information Society*, *15*(1), 1-10.

Attewell, P. (2001). Comment: The first and second digital divides. *Sociology of Education*, 252-259. Retrieved from http://www.emilienneireland.com/blackboard/sources/Attewell_Digital_Divide_2001.pdf.

Attewell, P., Battle, J., & Suazo-Garcia, B. (2003). Computers and young children: Social benefit or social problem? Social Forces, *82*(1), 277-296. Retrieved from http://mtw160-198.ippl.jhu.edu/journals/social_forces/v082/82.1attewell.pdf.

Baldauf, K., Amer, B., Gower-Winter, K., (2013). Emerge with Computer Learning. Cenage Learning. Retrieved from http://www.cengage.com/resource_uploads/downloads/1285780140_428378.pdf.

Bataineh, R., & Baniabdelrahman, A. (2006). Jordanian EFL students' perceptions of their computer literacy. *International Journal of Education and Development using ICT* [Online], *2*(2). Retrieved from http://ijedict.dec.uwi.edu/viewarticle.php?id=169.

Becker, H. J. (2000). Findings from the Teaching, Learning, and Computing Survey: Is Larry Cuban Right? Education Policy Analysis Archives, *8*(51), 51.

Behind, N.C.L. (2002). Act of 2001, Pub. L. No. 107-110, § 115.Stat, 1425, 107-110.

Beltran, D. O., Das, K. K., & Fairlie, R. W. (2008). Are Computers Good for Children? The effects of home computers on educational outcomes. Centre for Economic Policy Research, ANU. Retrieved from http://tinyurl.com/now56q5.

Beltran, D. O., Das, K., & Fairlie, R. W. (2010). Home computers and educational outcomes: evidence from the NLSY97 and CPS. FRB International Finance Discussion Paper, (958). Retrieved from http://tinyurl.com/qy5h3ar.

Ben Youssef, A., Dahmani, M. (2008). "The Impact of ICT on Student Performance in Higher Education: Direct effects, indirect effects and organizational change". In: "The Economics of E-learning" *Revista de Universidad y Sociedad del Conocimiento*. *5*(1), Retrieved from http://www.uoc.edu/rusc/5/1/dt/eng/benyoussef_dahmani.pdf.

Blanton, W. E., Moorman, G. B., Hayes, B. A., & Warner, M. L. (1997). Effects of participation in the Fifth Dimension on far transfer. *Journal of Educational Computing Research*, *16*(4), 371-396.

Blazer, C. (2008). Literature Review: Educational Technology. *Research Services, Miami-Dade County Public Schools*.

Borg, W. R., Gall, J. P., & Gall, M. D. (1993). Applying educational research: A practical guide.

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2008). Scaling the digital divide: Home computer technology and student achievement. In *Education Policy Colloquia Series, Harvard University*, Cambridge, MA.

Cohen, J. & Cohen. P. (1975). Applied multiple Regression/correlation analysis for the behavioral sciences. Hillsdale, NJ.

CompTIA. (2011). IT Opportunities in the Educational Market. Retrieved from https://www.comptia.org/resources/it-opportunities-in-the-education-market.

Cuban, L. (2009). *Oversold and underused: Computers in the classroom*. Harvard University Press. http://www.urosario.edu.co/urosario_files/28/28745b9b-7870-4676-9b0e-a84b26278639.pdf.

Cuban, L. (2010). Rethinking education in the age of technology: The digital revolution and schooling in America. *Science Education*, *94*(6), 1125-1127.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal*, *38*(4), 813-834.

Cuban, L., & Tyack, D. (1995). Tinkering toward utopia: A century of public school reform. *Nation. Cambridge, MA: Harvard University Press*.

D'Angelo, C., Touchman, S., Clark, D., O'Donnell, A., Mayer, R., Dean Jr., D., & Hmelo-Silver, C. (2009). Historical Roots of Constructivism. Retrieved from http://www.education.com/reference/article/constructivism/.

DeBell, M., & Chapman, C. (2006). Computer and Internet Use by Students in 2003. Statistical Analysis Report. NCES 2006-065.

Dias, L. B. (1999). Integrating technology. *Learning and Leading with Technology*, *27*, 10-13.

Dickinson, E. R. & Adelson, J. L. (2014). Exploring the Limitations of Measures of Students "Socioeconomic Status (SES). Practical Assessment, Research & Evaluation, *19*(1). Retrieved from http://pareonline.net/getvn.asp?v=19&n=1.

DiMaggio, P., Hargittai, E., Celeste, C., & Shafer, S. (2004). Digital inequality: From unequal access to differentiated use. *Social Inequality*, 355-400. Retrieved from http://tinyurl.com/pz2xjpw.

Duffy, T. M., & Jonassen, D. H. (Eds.). (1992). *Constructivism and the technology of instruction: A conversation*. Psychology Press.

Dynarski, M. (2007). Effectiveness of reading and mathematics software products findings from the first student cohort report. DIANE Publishing. Retrieved from: http://ies.ed.gov/ncee/pubs/20074005/.

Ertmer, P. A., & Ottenbreit-Leftwhich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42(*3). Retrieved from http://files.eric.ed.gov/fulltext/EJ882506.pdf.

Fairlie, Robert. (2014). The effects of home computers on school enrollment. *Economics of Education Review*. UC Santa Cruz: Department of Economics, UCSC. Retrieved from: http://escholarship.org/uc/item/82w8v1m8.

Fairlie, R. W. (2005). The effects of home computers on school enrollment. *Economics of Education Review*, UC Santa Cruz: Department of Economics, UCSC. *24*(5), 533-547. Retrieved from http://www.cjtc.ucsc.edu/docs/r_schoolcomp6.pdf.

Fairlie, R. W. (2012). Academic achievement, technology and race: Experimental evidence. *Economics of Education Review*, *31*(5), 663-679. Retrieved from http://www.kent.k12.wa.us/cms/lib/WA01001454/Centricity/Domain/568/Citations/Academic%20Achievement%20Technology%20and%20Race.pdf.

Fairlie, R. W., & London, R. A. (2012). The effects of home computers on educational outcomes: Evidence from a field experiment with community college students. *The Economic Journal*, *122*(561), 727-753. Retrieved from http://people.ucsc.edu/~rfairlie/papers/butte22.docx.

Fairlie, R. W., & Robinson, J. (2013). *Experimental evidence on the effects of home computers on academic achievement among schoolchildren* (No. w19060). *National Bureau of Economic Research*. Retrieved from http://archive.nyu.edu/bitstream/2451/31408/2/11_14.pdf.

Fouts, J. (2000). Research on computers and education: Past, present and future. Seattle, WA: The Bill and Melinda Gates Foundation.

Frost, J. (2012, April 5). Why You Need to Check Your Residual Plots for Regression Analysis: Or, o err is human, to err randomly is statistically divine. Retrieved from http://blog.minitab.com/blog/adventures-in-statistics/why-you-need-to-check-your-residual-plots-for-regression-analysis.

Frost, J. (2014, June 12). How to interpret a regression model with low R-squared and low P values. Retrieved from http://blog.minitab.com/blog/adventures-in-statistics/how-to-interpret-a-regression-model-with-low-r-squared-and-low-p-values.

Fuchs, T., and Woessman, L. (2004a). Computers and student learning: Bivariate and multivariate evidence on the availability and use of computers at home and at school (No. 1321). CESifo working papers. Retrieved from http://www.econstor.eu/bitstream/10419/18686/1/cesifo1_wp1321.pdf.

Fuchs, T., & Woessman, L. (2004b). *What accounts for international differences in student performance?* (No. 1235). CESifo working papers. Retrieved from http://www.econstor.eu/bitstream/10419/18874/1/cesifo1_wp1235.pdf.

Gall, M., Gall, J., & Borg, W. (2003). Educational Research. Boston, MA: Pearson Education, Inc.

Gall, M., Gall, J., & Borg, W. (2007) Educational Research: An introduction (8 th ed.). Boston, MA: Pearson Education, Inc.

Giacquinta, J. B. (1993).Beyond technology's promise: An examination of children's educational computing at home. Cambridge University Press.

Goolsbee, A., & Guryan, J. (2006). World wide wonder? Measuring the (non-) impact of internet subsidies to public schools. *Education Next*, *6*(1), 60-65.

Graves, M. (2009). Computer Technology Encyclopedia. Cenage Learning. New York: NY.

Higgins, S., Xiao, Z., & Katsipataki, M. (2012). The impact of digital technology on learning: A summary for the Education Endowment Foundation. Retrieved from https://educationendowmentfoundation.org.uk/uploads/pdf/The_Impact_of_Digital_Technologies_on_Learning_(2012).pdf.

Inan, F. A., & Lowther, D. L. (2010). Factors affecting technology integration in K-12 classrooms: A path model. *Educational Technology Research and Development*, *58*(2), 137-154.

ISTE® (International Society for Technology in Education) (2008). ISTE® policy brief—technology and student achievement—The Indelible Link. Washington, DC: Retrieved from http://www.k12hsn.org/files/research/Technology/ISTE_policy_brief_student_achievement.pdf.

ISTE® (International Society for Technology in Education) (2012). The ISTE Standards and NCATE (National Council for Accreditation of Teacher Education). Washington, DC: Retrieved from http://www.iste.org/standards.

Jackson, L. A., Von Eye, A., Biocca, F. A., Barbatsis, G., Zhao, Y., & Fitzgerald, H. E. (2001). *Computers in Human Behavior, 27*(1), 228-239.

Jackson, L. A., Von Eye, A., Biocca, F. A., Barbatsis, G., Zhao, Y., & Fitzgerald, H. E. (2006). Does home internet use influence the academic performance of low-income children? *Developmental Psychology*, *42*(3), 429.

Johnson, K.A. (2000). Do computers in the classroom boost academic achievement? A report of the Heritage Center for Data Analysis. Retrieved from http://www.heritage.org./Research/Education/CDA00-08.cfm.

Keller, J. (2009). Studies explore whether the internet makes students better writers. *Journal of Higher Education.*

Kolikant, Y. B.-D. (2012). Using ICT for school purposes: Is there a student-school disconnect? *Computers & Education*, *59*(3), 907. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CA294942932&v=2.1&u=qa_mig19&it=r&p=AONE&sw=w&asid=475b54056ea084a975f48814241db770.

Kmitta, D., & Davis, J. (2004). Why PT3? An analysis of the impact of educational technology. Contemporary Issues in Technology Teacher Education, *4*(3), 323-344.

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review of Education*, *38*(1), 9-24. Retrieved from http://tinyurl.com/o7zk9dv.

Lemke, C., & Martin, C. (2003). One-to-one computing in Maine: A state profile. Los Angeles, CA: Metiri Group. Retrieved from http://westsidecs.wms.schoolfusion.us/modules/groups/homepagefiles/cms/701787/File/laptopresearch/ME-Profile.pdf.

Lenhart, A., Arafeh, S., & Smith, A. (2008). Writing, Technology and Teens. *Pew Internet & American Life Project.*

Li, X., Atkins, M. S., & Stanton, B. (2006). Effects of home and school computer use on school readiness and cognitive development among Head Start children: A randomized controlled pilot trial. *Merrill-Palmer Quarterly*, *52*(2), 239-263.

Loges, W. E., & Jung, J. Y. (2001). Exploring the digital divide internet connectedness and age. *Communication Research*, *28*(4), 536-562.

Lowther, D. L., Ross, S. M., & Morrison, G. R. (2001). Evaluation of a laptop program: Successes and recommendations. 2001 National Educational Computing Conference Proceedings. Eugene, OR, Retrieved from http://amoyemaat.org/lowther.pdf.

Mahlamud, O., & Pop-Eleches, C. (2011). Home computer use and the development of human capital. *The Quarterly Journal of Economics*, *126*(2), 987-1027.

McHugh M. L., (2008). Standard error: meaning and interpretation. *Biochemia Medica*, *18*(1), 7-13. Retrieved from http://dx.doi.org/10.11613/BM.2008.002.

Megarry, J. (2013). Thinking, learning, and educating: The role of the computer. World Yearbook of Education 1982/83: *Computers and Education*, 15-28.

Mitchell Institute. (2004). One-to-one Laptops in a High School Environment, Piscataquis Community High School Study Final Report. Great Maine Schools Project.

Muir, M., Knezek, G., & Christensen, R. (2004). The Power. *Learning & Leading with Technology*, *32*(3), 6. Retrieved from http://www.eastpennsd.org/Committees/techcomm/techcommpics/laptopinitiative.pdf

National Telecommunications and Information Administration. (1999). Falling Through the Net—Defining the Digital Divide: A report on the telecommunications and information technology gap in America. U.S. Department of Commerce. Retrieved from www.ntia.doc.gov/ntiahome/fttn99/contents.html.

North Carolina Department of Public Instruction. (2005). IMPACT: Guidelines for North Carolina media and technology programs. Raleigh, NC.

North Central Regional Educational Laboratory [NCREL]. (2005). Critical Issue: Using technology to improve student achievement. Retrieved from http://www.ncrel.org/sdrs/areas/issues/methods/technlgy/te800.htm#contact.

Oppenheimer, T. (1997). The computer delusion. *The Atlantic Monthly*, *280*(1), 45-62.

Papanastasiou, E. C., Zemblyas, M., & Vrasidas, C. (2003). Can computer use hurt science achievement? The USA results from PISA. *Journal of Science Education and Technology*, *12*(3), 325-332. Retrieved from http://vrasidas.com/wp-content/uploads/2007/07/science.pdf.

Papert, S. (1996). Computers in the classroom: Agents of change. *The Washington Post education review*. Retrieved from http://ucladodgeroz.tripod.com/Printables/Papert.doc.

Papert, S. (1999). Vision for education: The Caperton-Papert platform. Retrieved from http://www.papert.org/articles/Vision_for_education.html.

Papert, S., & Harrell, I. (1991). Situating constructionism. *Constructionism*, *36*, 1-11.

Peck, C., Cuban, L., & Kirkpatrick, H. (2002). Techno-promoter dreams, student realities. *Phi Delta Kappan*, *83*(6), 472-480.

Rabalais, M. (2014). STEAM: A national study of the integration of the arts into STEM instruction and its impact on student achievement. Retrieved via email from author.

Rajarman, V. (2010). Fundamentals of Computers. Phi Learning Pvt. Ltd.

Reiser, R. A. (2002). A history of instructional design and technology., In R.A. Reiser & J.V. Dempsey (Eds.),Trends and issues in instructional design and technology., Upper Saddle River, NJ: Merrill Prentice Hall.

Roberts, D. F., Foehr, U. G., & Rideout, V. J. (2005). *Generation M: Media in the lives of 8-18 year-olds*. Retrieved from http://tinyurl.com/omoakj2

Rockman, S. (2004). Getting results with laptops. *Technology & Learning*, *25*(3), 1-12. Retrieved from http://www.sca2006.tic-educa.org/archivos/modulo_2/sesion_3/getting_results_with_laptops.pdf.

Rouse, C. E., & Krueger, A. B. (2004). Putting computerized instruction to the test: a randomized evaluation of a “scientifically based” reading program. *Economics of Education Review, 23*(4), 323-338.

Salkind, N. J., (2011). Statistics for people who (think they) hate statistics (4th ed.). Thousand Oaks, CA: Sage Publications, Inc.

Samuelson, P. and Varian, H.R. (2001). The “New Economy” and information technology policy. University of California, Berkeley, CA: Retrieved from http://people.ischool.berkeley.edu/~pam/papers/infopolicy.

Schmitt, J., & Wadsworth, J. (2006). Is there an impact of household computer ownership on children's educational attainment in Britain? *Economics of Education Review*, *25*(6), 659-673.

Silvernail, D. L., & Lane, D. M. (2005). The impact of Maine's one-to-one laptop program on middle school teachers and students. Maine Education Policy Research Institute (MEPRI), University of Southern Maine. Retrieved from http://tinyurl.com/q65d4r8

Silvernail, D. L., & Gritter, A. K. (2007). Maine's middle school laptop program: Creating better writers. Retrieved from http://tinyurl.com/nbg5kxe.

Spiezia, V. (2010). Does computer use increase educational achievements? Student-level evidence from PISA. Retrieved from http://tinyurl.com/owoafb5.

State Educational Technology Directors Association, SETDA (2008). SETDA's National Trend Report Highlights of 2008. Retrieved from http://www.setda.org/wp-content/uploads/2013/12/NationalTrendsPamphlet2008PrintFriendly.pdf.

State Educational Technology Directors Association, SETDA (2012). AARA Case Studies 2012. Retrieved from http://www.setda.org/wp-content/uploads/2013/12/case-studies-ARRA_Case_Studies_20122.pdf.

Stevens, T., (2012). Research findings on the effects of one-to-one student computing. Retrieved from http://tinyurl.com/pzbgblj.

Stoll, C. (1996). Silicon snake oil: Second thoughts on the information highway. New York, NY: Random House LLC.

Straumshein, C., (2015). EdTech's Funding Frenzy. InsideHigherEd. Retrieved from https://www.insidehighered.com/news/2015/07/24/investments-ed-tech-companies-reach-new-high-first-half-2015.

Strommen, E.F. and Lincoln, B., (1992). Constructivism, technology, and the future of classroom learning. *Education and Urban Society,* 24, 4, 466-476, New York, NY: Retrieved from http://m.alicechristie.org/classes/530/constructivism.pdf.

Sun, L. & Bradley, K.D. (2010). Using the U.S. PISA results to investigate the relationship between school computer use and student academic performance. Retrieved from http://www.uky.edu/kdbrad2/MWERA_Letao.pdf.

Swan K., & Mitrani, M. (1993). The changing nature of teaching and learning in computer-based classrooms. *Journal of Research on Computing in Education, 26*(1), 40-54.

Texas Center for Educational Research. (2008). Evaluation of the Texas technology immersion pilot: Outcomes for the third year (2006-2007). Austin, TX: TCER. Retrieved from http://www.tea.state.tx.us/WorkArea/DownloadAsset.aspx?id=2147497816.

Thomas, K. M., & McGee, C. D. (2012). The only thing we have to fear is… 120 characters. *TechTrends*, *56*(1), 19-33.

Thomson, D. L. (2010). Beyond the classroom walls: Teachers and students perspectives on how online learning can meet the needs of gifted students. *Journal of Advanced Academics*, *21*(4), 662-712.

Underwood, J., Billingham, M., & Underwood, G. (1994). Predicting computer literacy: How do the technological experiences of schoolchildren predict their computer-based problem-solving skills? *Journal of Information Technology for Teacher Education*, *3*(1), 115-126.

U. S. Department of Education, National Center for Education Statistics, (NCES). (1999). *Teacher quality: A report on the preparation and qualifications of public school teachers*. Washington, DC: NCES 1999–080.

U. S. Department of Education, National Center for Education Statistics, (NCES). (2000). *Internet access in U. S. public schools and classrooms: 1994–99*. Washington, DC: NCES 2000–086.

U. S. Department of Education. National Center for Education Statistics, (NCES). (2000). Teachers' tools for the 21st century: A report on teacher's use of technology. Washington, DC: NCES 2000102.

U. S. Department of Education, Office of Educational Research and Improvement. (1995). *National Educational Longitudinal Study* (*NELS: 88/94*) *Methodology Report*, Washington, DC: NCES 96-174.

U. S. Department of Education. (2004). *National Education Technology Plan*. Jessup, MD: Editorial Publications Center.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES), National Assessment of Educational Progress (NAEP) (2004). Science Assessment. Washington, DC.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES), National Assessment of Educational Progress (NAEP) (2009). Science Assessment. Washington, DC.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES), National Assessment of Educational Progress (NAEP) (2009). Science Assessment. Washington, DC. Retrieved from http://www.nationsreportcard.gov/science_2009/science_2009_report.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES), National Assessment of Educational Progress (NAEP) (2009). Science Assessment. Washington, DC. Retrieved from http://www.nationsreportcard.gov/science_2009/summary.aspx.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES) National Assessment of Educational Progress (NAEP), National Assessment Governing Board. (n.d.). Retrieved from http://www.nagb.org/toolbar/faqs.html#naep-design).

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES) National Assessment of Educational Progress (NAEP), National Assessment Governing Board. (n.d.). Retrieved from http://nces.ed.gov/nationsreportcard/about/nathow.asp.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics NCES. (2011). *Technical Notes*. Retrieved from http://nces.ed.gov/nationsreportcard/pdf/main2011/2012465.pdf.

U.S. Census Bureau (2012). Computer and Internet Access in the United States: 2012, Table 1. Reported Internet Usage for Individuals 3 Years and Older, by Selected Characteristics: 2012, Retrieved from http://www.census.gov/hhes/computer/publications/2012.html.

VanderMey, A. (2015). Fortune Online. 12 Disruptive Tech Trends. Retrieved from http://fortune.com/2015/07/22/mckinsey-disruptive/.

Vigdor, J. L., & Ladd, H. F. (2010). *Scaling the digital divide: Home computer technology and student achievement* (No. w16078). Cambridge, MA: National Bureau of Economic Research.

Vigdor, J. L., Ladd, H. F., Martinez, E. (2014). Scaling the digital divide: Home computer technology and student achievement, *Economic Inquiry 52*(3), 1103-1119.

Warschauer, M. (1997). Computer-mediated collaborative learning: Theory and practice. *The Modern Language Journal*, *81*(4), 470-481.

Warschauer, M. (2003). Demystifying the digital divide. *Scientific American*, *289*(2), 42-47.

Warschauer, M. (2004).Technology and social inclusion: Rethinking the digital divide. Boston, MA: MIT press.

Warschauer, M. (2006). Laptops and literacy: A multi-site case study. *Pedagogies: An International Journal*, *3*(1), 52-67. Retrieved from http://gse.uci.edu/person/warschauer_m/docs/ll-pedagogies.pdf.

Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education, 34*(1), 179-225. Retrieved from http://gse.uci.edu/person/warschauer_m/docs/equity.pdf.

Waxman, H. C., & Huang, S. L. (1996). Classroom instruction differences by level of technology use in middle school math. *Journal of Educational Computing Research, 14*, 147-159.

Waxman, H.C., Meng-Fen L., & Michko. G. M. (2003). A Meta-analysis of the effectiveness of teaching and learning with technology on student outcomes. Houston, TX: University of Houston.

Wenglinsky, H. (1998). Does it compute? The relationship between educational technology and student achievement in mathematics. Princeton, NJ: Educational Testing Service. Retrieved from http://www.ets.org/Media/Research/pdf/PICTECHNOLOG.pdf.

Wenglinsky, H. (2005). Technology and achievement: The bottom line. Educational Leadership, 63(4), 29.

Winkleby, M. A., Jatulis, D. E., Frank, E., & Fortmann, S. P. (1992). Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *American journal of public health*, *82*(6), 816-820. Retrieved from http://ajph.aphapublications.org/doi/abs/10.2105/AJPH.82.6.816.

Zar. J. H. (2009). Biostatistical analysis. (5th ed.). New York, NY: Pearson.

Tables

Table 1.

Study Variables, Definitions and Measures

Variable	Measure	Value
Dependent		
NAEP Science Achievement Score	Description: NAEP Science Scale: Overall ID: SRPUV	0-300
Independent		
Computer at Home	NAEP question ID: B017101 Is there a computer at home that you use? (student-reported)	Yes, No
Controlled		
Gender	NAEP question ID: GENDER Gender of student as taken from school records	Male, Female
Race	NAEP question ID: SDRACE School-reported race/ethnicity (supplemented in some cases by student self-reported data)	White, Black, Hispanic, Asian/Pacific Islander, American Indian/Alaska Native, Two or more races
National School Lunch Program (SES)	Full Title: Student eligibility for National School Lunch Program based on school records (collapsed to three categories, as included in NAEP reports) ID: SLUNCH3	Eligible, Not Eligible
Parental Education Level	Full Title: Parental education: Highest level achieved by either parent (based on student responses to two background questions) ID: PARED	Did not finish high school, Graduated high school, Some education after high school, Graduated college, Unknown

NOTE: Criteria, measures, jurisdiction, and variable information from NAEP Data Explorer (2011). See http://nces.ed.gov.nationsreportcard/hstsdata

Table 2.

Average Scale Scores for Science, Grade 12 by Computer at Home [B017101], Jurisdiction, Year and All Students [TOTAL]: 2009

		Yes		No	
Year	**Jurisdiction**	Average scale score	Standard Error	Average scale score	Standard Error
2009	National Public	151	(0.9)	127	(2.2)

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 3.

Average Scale Scores for Science, Grade 12 by All Students [TOTAL], National School Lunch Program Eligibility, 3 Categories [SLUNCH3],Jurisdiction, Year and Computer at Home [B017101]: 2009

			All students					
			All students					
			National School Lunch Program eligibility, 3 categories					
			Eligible		**Not eligible**		**Information not available**	
Year	**Jurisdiction**	**Computer at home**	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error
2009	**National public**	**Yes**	134	(1.0)	157	(0.8)	147	(7.4)
		No	123	(2.4)	132	(3.5)	‡	(†)

† Not applicable.

‡ Reporting standards not met.

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 4.

Average Scale Scores for Science, Grade 12 by Parental Education Level, from 2 Questions [PARED], Year, Jurisdiction and Computer at Home [B017101]: 2009

			Did not finish high school		Graduated high school		Some education after high school		Graduated college		Unknown	
Year	**Jurisdiction**	**Computer at home**	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error
2009	**National public**	**Yes**	133	(1.4)	139	(1.3)	148	(0.9)	161	(0.8)	123	(2.3)
		No	121	(4.6)	125	(3.5)	132	(4.0)	137	(3.1)	‡	(†)

† Not applicable.

‡ Reporting standards not met.

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 5.

Average Scale Scores for Science, Grade 12 by National School Lunch Program Eligibility, 2 Categories [SLUNCH3], Parental Education Level, From 2 Questions [PARED], Jurisdiction, Year and Computer at Home [B017101]: 2009

			Eligible						Not eligible					
			Parental education level, from 2 questions						Parental education level, from 2 questions					
			Did not finish high school		Graduated high school		Graduated college		Did not finish high school		Graduated high school		Graduated college	
			Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error
National public	**2009**	**Yes**	132	(1.7)	131	(1.8)	137	(1.9)	134	(2.3)	145	(1.6)	166	(0.8)
		No	120	(4.9)	123	(3.5)	127	(4.5)	‡	(†)	‡	(†)	‡	(†)

† Not applicable.

‡ Reporting standards not met.

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 6.

Average Scale Scores for Science, Grade 12 by All Students [TOTAL], Race/Ethnicity Used to Report Trends, School - Reported [SDRACE], Year, Jurisdiction and Computer at Home [B017101]: 2009

			All students									
			Race/ethnicity used to report trends, school-reported									
			White		**Black**		**Hispanic**		**Asian/Pacific Islander**		**American Indian/Alaska Native**	
Year	**Jurisdiction**	**Computer at home**	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error
2009	National public	Yes	160	(0.7)	126	(1.4)	135	(1.3)	165	(3.4)	‡	(†)
		No	138	(2.4)	113	(3.3)	121	(3.0)	‡	(†)	‡	(†)

† Not applicable.

‡ Reporting standards not met.

Black includes African American, Hispanic includes Latino, and Pacific Islander includes Native Hawaiian. Race categories exclude Hispanic origin. Prior to 2011, students in the “two or more races” category were categorized as “unclassified”. The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 7.

Average Scale Scores for Science, Grade 12 by All Students [TOTAL], Gender [GENDER], Year, Jurisdiction a nd Computer at Home [B017101]: 2009

			All students			
			Gender			
			Male		**Female**	
Year	**Jurisdiction**	**Computer at home**	Average scale score	Standard Error	Average scale score	Standard Error
2009	**National public**	**Yes**	154	(0.9)	148	(1.0)
		No	128	(3.1)	125	(2.5)

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 8.

Model 1 Regression Multiple Correlation R Squared, SES, Gender, Computer Access at Home

2009 NAEP Science Grade 12

Multiple Correlation	0.34
R Squared	0.11

	Degrees of Freedom	**Mean Square**	**F Ratio**	**P Value**
Model	4	98683531.97	69.45	0
Error	2148.68	1421015.15		

	Standardized Regression Coefficients	**S.E. of Standardized Coefficients**	**Regression Coefficients**	**S.E. of Regression Coefficients**	**T Statistic**	**Probability**	**Significance**
Intercept	0	0	137.4705	1.0515	130.7337	0	>
Gender							
Female	-0.0741	0.0122	-5.1977	0.8594	-6.0478	0	<
National School Lunch Program eligibility							

Not Eligible	0.2933	0.0134	22.141	1.1017	20.0993	0	>
Information not available	0.0443	0.031	12.1428	8.0045	1.517	0.1731	=
Computer at home							
No	-0.1132	0.0147	-16.4675	2.2348	-7.3687	0	<

	Mean	**SD**
Science	148.97	35.11

	Percentage	**SD**
Gender		
Female	51	50
NSLP eligibility		
Not eligible	68	46
Information not available	2	13
Computer at home		
No	6	24

NOTE: Dependent Variable: Overall science scale

Independent Variable(s): Gender [GENDER] , National School Lunch Program eligibility, 3 categories [SLUNCH3] , Computer at home [B017101].

Contrast Coding Reference Group: Male; Eligible; Yes National public: A 0-1 contrast coding has been used where the first subgroup of the (independent) variable is the reference group. Except for the reference group, each subgroup is contrasted (code 1) in a separate dummy variable against all the other subgroups of the variable (code 0).

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 9.

Parameter Estimates, Significance Test for Gender, SES & Computer Access at Home

Variable	**Regression Coefficients**	**Std. Error**	**T Statistic**	**P value**
Intercept	137.471	1.052	130.734	<.001
Gender (Female)	-5.198	0.859	-6.048	<.001
Lunch (Not eligible)	22.144	1.102	20.093	<.001
Computer access (No)	-16.468	2.235	-7.369	<.001

NOTE: A 0-1 contrast coding has been used where the first subgroup of the (independent) variable is the reference group. Except for the reference group, each subgroup is contrasted (code 1) in a separate dummy variable against all the other subgroups of the variable (code 0). For more details about contrast coding with multiple variables see the help documentation.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES), National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table 10.

Model 2 Regression Multiple Correlation R Squared, Race, Gender, Computer Access at Home

2009 NAEP Science Grade 12

Multiple Correlation		0.43		
R Squared		0.18		
	Degrees of Freedom	**Mean square**	**F Ratio**	**P Value**
Model	8	78363081.71	115.07	0
Error	4142.64	681000.5		

	Standardized Regression Coefficients	**S.E. of Standardized Coefficients**	**Regression Coefficients**	**S.E. of Regression Coefficients**	**T Statistic**	**Probability**	**Sig.**
Intercept	0	0	163.1745	0.8315	196.2367	0	>
Gender							
Female	-0.0837	0.0116	-5.8679	0.8135	-7.2133	0	<
Race/ethnicity							
Black	-0.3271	0.0138	-33.3953	1.3845	-24.121	0	<
Hispanic	-0.2856	0.0141	-24.1741	1.1805	-20.4784	0	<
Asian/Pacific Islander	0.0242	0.0255	3.4369	3.4997	0.982	0.3455	=
American Indian/Alaska Native	-0.0303	0.0104	-13.5173	4.6878	-2.8835	0.0064	<
More than one	-0.033	0.0122	-5.739	2.1382	-2.684	0.0093	<
Unclassified	-0.007	0.0114	-17.3121	23.6631	-0.7316	0.4972	=
Computer at home							
No	-0.1127	0.0134	-16.3919	2.0535	-7.9824	0	<

Mean	**SD**

Science	148.97	35.11
	Percentage	**SD**
Gender		
Female	51	50
Race/ethnicity allowing multiple responses, student-reported		
Black	14	34
Hispanic	22	41
Asian/Pacific Islander	7	25
American Indian/Alaska Native	1	8
Computer at home		
No	6	24

NOTE: A 0-1 contrast coding has been used where the first subgroup of the independent variable is the reference group. Except for the reference group, each subgroup is contrasted (code 1) in a separate dummy variable against all the other subgroups of the variable (code 0).

SOURCE: U.S. Dept. of Education, IES, NCES, NAEP 2009 Science Assessment.

Table 11.

Parameter Estimates, Significance Test for Gender, Race and Computer Access

Variable	**Regression Coefficients**	**Std. Error**	**T Statistic**	**P value**
Intercept	163.175	0.8325	196.237	<.001
Gender (Female)	-5.868	0.814	-7.213	<.001
Race (Black)	-33.395	1.385	-24.121	<.001
Race (Hispanic)	-24.174	1.181	-20.478	<.001
Race (Asian/Pacific Islander)	3.437	3.499	0.982	.346
Race (American Indian/Alaska Native)	-13.517	4.688	-2.884	.006
Computer Access (No)	-16.392	2.054	-7.982	<.001

NOTE: A 0-1 contrast coding has been used where the first subgroup of the (independent) variable is the reference group. Except for the reference group, each subgroup is contrasted (code 1) in a separate dummy variable against all the other subgroups of the variable (code 0). For more details about contrast coding with multiple variables see the help documentation.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (NCES), National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Appendix A

Table A1.

Average Scale Scores for Science, Grade 12 by All Students [TOTAL], Year and Jurisdiction: 2009

		All students	
Year	**Jurisdiction**	Average scale score	Standard Error
2009	**National public**	149	(0.9)

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table A2.

Science, Grade 12 Difference in Average Scale Scores Between Variables, for Computer at Home [B017101] National Public, 2009, Cross Tabulation

	Yes	**No**
Yes		>Diff = 24P-value = 0.0000
No	<Diff = -24P-value = 0.0000	

LEGEND:

<	Significantly lower.
>	Significantly higher.
X	No significant difference.

NOTE: All comparisons are independent tests with an alpha level of 0.05 adjusted for multiple pairwise comparisons according to the False Discovery Rate procedure. For comparisons between two jurisdictions, a dependent test is performed for cases where one jurisdiction is contained in the other. For more detailed information about the procedures and family sizes please see the Help document.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table A3.

Science, grade 12, Difference in Average Scale Scores Between Variables, for National School Lunch Program Eligibility, 2 Categories [SLUNCH3] by Computer at Home [B017101]National Public, 2009

	Eligible Yes(134)	**Eligible No(123)**	**Not eligible Yes(157)**	**Not eligible No(132)**
Eligible Yes(134)		> Diff = 10 P-value = 0.0001 Family size = 6	< Diff = -23 P-value = 0.0000 Family size = 6	x Diff = 2 P-value = 0.6478 Family size = 6
Eligible No(123)	< Diff = -10 P-value = 0.0001 Family size = 6		< Diff = -34 P-value = 0.0000 Family size = 6	x Diff = -9 P-value = 0.0456 Family size = 6
Not eligible Yes(157)	> Diff = 23 P-value = 0.0000 Family size = 6	> Diff = 34 P-value = 0.0000 Family size = 6		> Diff = 25 P-value = 0.0000 Family size = 6
Not eligible No(132)	x Diff = -2 P-value = 0.6478 Family size = 6	X Diff = 9 P-value = 0.0456 Family size = 6	< Diff = -25 P-value = 0.0000 Family size = 6	

LEGEND:

< Significantly lower. > Significantly higher. X No significant difference.

NOTE: All comparisons are independent tests with an alpha level of 0 .05 adjusted for multiple pairwise comparisons according to the False Discovery Rate procedure. For comparisons between two jurisdictions, a dependent test is performed for cases where one jurisdiction is contained in the other. For more detailed information about the procedures and family sizes please see the Help document.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table A4.

Science, Grade 12, Difference in Average Scale Scores Between Variables, For Computer at Home [B017101] by Parental Education Level, From 2 Questions [PARED] National Public, 2009

	Yes **Did not finish high school(133)**	**Yes** **Graduated high school(139)**	**Yes** **Some education after high school(148)**	**Yes** **Graduated college(161)**	**No** **Did not finish high school(121)**	**No** **Graduated high school(125)**	**No** **Some education after high school(132)**	**No** **Graduated college(137)**
Yes **Did not finish high school(133)**		< Diff = -6 P-value = 0.0014 Family size = 28	< Diff = -15 P-value = 0.0000 Family size = 28	< Diff = -28 P-value = 0.0000 Family size = 28	> Diff = 12 P-value = 0.0156 Family size = 28	> Diff = 9 P-value = 0.0274 Family size = 28	x Diff = 1 P-value = 0.8521 Family size = 28	x Diff = -3 P-value = 0.3091 Family size = 28
Yes **Graduated high school(139)**	> Diff = 6 P-value = 0.0014 Family size = 28		< Diff = -8 P-value = 0.0000 Family size = 28	< Diff = -22 P-value = 0.0000 Family size = 28	> Diff = 18 P-value = 0.0004 Family size = 28	> Diff = 15 P-value = 0.0002 Family size = 28	x Diff = 7 P-value = 0.1261 Family size = 28	x Diff = 3 P-value = 0.4211 Family size = 28
Yes **Some education after high school(148)**	> Diff = 15 P-value = 0.0000 Family size = 28	> Diff = 8 P-value = 0.0000 Family size = 28		< Diff = -14 P-value = 0.0000 Family size = 28	> Diff = 26 P-value = 0.0000 Family size = 28	> Diff = 23 P-value = 0.0000 Family size = 28	> Diff = 15 P-value = 0.0034 Family size = 28	> Diff = 11 P-value = 0.0010 Family size = 28
Yes **Graduated college(161)**	> Diff = 28 P-value = 0.0000 Family size = 28	> Diff = 22 P-value = 0.0000 Family size = 28	> Diff = 14 P-value = 0.0000 Family size = 28		> Diff = 40 P-value = 0.0000 Family size = 28	> Diff = 37 P-value = 0.0000 Family size = 28	> Diff = 29 P-value = 0.0000 Family size = 28	> Diff = 25 P-value = 0.0000 Family size = 28
No **Did not finish high school(121)**	< Diff = -12 P-value = 0.0156 Family size = 28	< Diff = -18 P-value = 0.0004 Family size = 28	< Diff = -26 P-value = 0.0000 Family size = 28	< Diff = -40 P-value = 0.0000 Family size = 28		x Diff = -3 P-value = 0.5598 Family size = 28	x Diff = -11 P-value = 0.0761 Family size = 28	< Diff = -15 P-value = 0.0065 Family size = 28

No Graduated high school(125)	< Diff = -9 P-value = 0.0274 Family size = 28	< Diff = -15 P-value = 0.0002 Family size = 28	< Diff = -23 P-value = 0.0000 Family size = 28	< Diff = -37 P-value = 0.0000 Family size = 28	x Diff = 3 P-value = 0.5598 Family size = 28		x Diff = -8 P-value = 0.1599 Family size = 28	< Diff = -12 P-value = 0.0118 Family size = 28
No Some education after high school(132)	X Diff = -1 P-value = 0.8521 Family size = 28	x Diff = -7 P-value = 0.1261 Family size = 28	< Diff = -15 P-value = 0.0034 Family size = 28	< Diff = -29 P-value = 0.0000 Family size = 28	x Diff = 11 P-value = 0.0761 Family size = 28	x Diff = 8 P-value = 0.1599 Family size = 28		x Diff = -4 P-value = 0.4086 Family size = 28
No Graduated college(137)	X Diff = 3 P-value = 0.3091 Family size = 28	x Diff = -3 P-value = 0.4211 Family size = 28	< Diff = -11 P-value = 0.0010 Family size = 28	< Diff = -25 P-value = 0.0000 Family size = 28	> Diff = 15 P-value = 0.0065 Family size = 28	> Diff = 12 P-value = 0.0118 Family size = 28	x Diff = 4 P-value = 0.4086 Family size = 28	

LEGEND:

< Significantly lower.

> Significantly higher.

X No significant difference.

NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table A5.

Science, grade 12, Difference in average scale scores between variables, for computer at home [B017101] by race/ethnicity used to report trends, school-reported [SDRACE]National public, 2009

	Yes **White(160)**	**Yes** **Black(126)**	**Yes** **Hispanic(135)**	**No** **White(138)**	**No** **Black(113)**	**No** **Hispanic(121)**
Yes **White(160)**		> Diff = 33 P-value = 0.0000 Family size = 21	> Diff = 25 P-value = 0.0000 Family size = 21	> Diff = 21 P-value = 0.0000 Family size = 21	> Diff = 46 P-value = 0.0000 Family size = 21	> Diff = 38 P-value = 0.0000 Family size = 21
Yes **Black(126)**	< Diff = -33 P-value = 0.0000 Family size = 21		< Diff = -9 P-value = 0.0000 Family size = 21	< Diff = -12 P-value = 0.0001 Family size = 21	> Diff = 13 P-value = 0.0011 Family size = 21	x Diff = 5 P-value = 0.1413 Family size = 21
Yes **Hispanic(135)**	< Diff = -25 P-value = 0.0000 Family size = 21	> Diff = 9 P-value = 0.0000 Family size = 21		x Diff = -3 P-value = 0.2178 Family size = 21	> Diff = 21 P-value = 0.0000 Family size = 21	> Diff = 14 P-value = 0.0001 Family size = 21
Yes **Asian/Pacific Islander(165)**	x Diff = 5 P-value = 0.1708 Family size = 21	> Diff = 38 P-value = 0.0000 Family size = 21	> Diff = 30 P-value = 0.0000 Family size = 21	> Diff = 26 P-value = 0.0000 Family size = 21	> Diff = 51 P-value = 0.0000 Family size = 21	> Diff = 43 P-value = 0.0000 Family size = 21

No White(138)	< Diff = -21 P-value = 0.0000 Family size = 21	> Diff = 12 P-value = 0.0001 Family size = 21	x Diff = 3 P-value = 0.2178 Family size = 21		> Diff = 25 P-value = 0.0000 Family size = 21	> Diff = 17 P-value = 0.0000 Family size = 21	
No Black(113)	< Diff = -46 P-value = 0.0000 Family size = 21	< Diff = -13 P-value = 0.0011 Family size = 21	< Diff = -21 P-value = 0.0000 Family size = 21	< Diff = -51 P-value = 0.0000 Family size = 21	< Diff = -25 P-value = 0.0000 Family size = 21		x Diff = -8 P-value = 0.0857 Family size = 21
No Hispanic(121)	< Diff = -38 P-value = 0.0000 Family size = 21	x Diff = -5 P-value = 0.1413 Family size = 21	< Diff = -14 P-value = 0.0001 Family size = 21	< Diff = -43 P-value = 0.0000 Family size = 21	< Diff = -17 P-value = 0.0000 Family size = 21	x Diff = 8 P-value = 0.0857 Family size = 21	

LEGEND:

<	Significantly lower.
>	Significantly higher.
X	No significant difference.

‡ Reporting standards not met.

NOTE: Black includes African American, Hispanic includes Latino, and Pacific Islander includes Native Hawaiian. Race categories exclude Hispanic origin. The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table A6.

Science, Grade 12, Difference in Average Scale Scores Between Variables, for Computer at Home [B017101] by All Students [TOTAL] by Gender [GENDER]National Public, 2009

	Yes All students Male (154)	Yes All students Female (148)	No All students Male (128)	No All students Female (125)
Yes All students Male (154)		> Diff = 6 P-value = 0.0000 Family size = 6	> Diff = 25 P-value = 0.0000 Family size = 6	> Diff = 29 P-value = 0.0000 Family size = 6
Yes All students Female (148)	< Diff = -6 P-value = 0.0000 Family size = 6		> Diff = 19 P-value = 0.0000 Family size = 6	> Diff = 23 P-value = 0.0000 Family size = 6
No All students Male (128)	< Diff = -25 P-value = 0.0000 Family size = 6	< Diff = -19 P-value = 0.0000 Family size = 6		x Diff = 3 P-value = 0.4029 Family size = 6
No All students Female (125)	< Diff = -29 P-value = 0.0000 Family size = 6	< Diff = -23 P-value = 0.0000 Family size = 6	x Diff = -3 P-value = 0.4029 Family size = 6	

LEGEND:

< Significantly lower.

> Significantly higher.

X No significant difference.

NOTE: All comparisons are independent tests with an alpha level of 0.05 adjusted for multiple pairwise comparisons according to the False Discovery Rate procedure. For comparisons between two jurisdictions, a dependent test is performed for cases where one jurisdiction is contained in the other.

Appendix B

Table B1.

Results Summary

Variable	**Measure Identification**	**Definition**	**Scale of Measurement**	**Result**
Computer at Home	CompHome	Do you have a computer at home?	Yes, No	Significant
National School Lunch Program	SES	Identification of lunch eligibility for grade 12 students participating in the 2009 NAEP assessments	Eligible, Not Eligible	Significant
Parental Education Level	PARED	Highest level achieved by either parent	Did not finish high school, Graduated high school, Some education after high school, Graduated college, Unknown	Significant
Race	RACE	Identification of race for grade 12 students participating in the 2009 NAEP assessments	Black, Hispanic, White	Significant
Gender	SEX	Identification of gender for grade 12 students participating in the 2009 NAEP assessments	Male, Female	Significant

Note: Criteria, measures, jurisdiction, and variable information from NAEP NDE (2011).

Source: http://nces.ed.gov.nationsreportcard/hstsdata

Table B2.

Average Score Summary of Students by Access to a Computer at Home

	2009 NAEP Grade12 Scores		
Variable Group	**Mean**	**Standard error**	**P value**
Asian	165	3.4	<.171
Parent Graduated College	161	0.80	<.001
White	160	0.70	<.001
High SES	157	0.80	<.001
Male	154	0.90	<.001
All groups in study	147	1.00	<.001
*National Average w/ & w/o**	149 (150)	1.00	<.000
Female	148	1.00	<.001
American In./Alaska Native	144	4.68	<.006
Hispanic	135	1.30	<.001
Low SES	134	2.40	<.001
Parent Did Not Graduate High School	133	1.40	<.001
Black	126	1.40	<.001

* Note: U.S. National Public School Student Average grade 12 science score

** Source: NAEP 2009

Table B3.

Average Scale Scores for Science, Grade 12 by National School Lunch Program Eligibility, 3 Categories [SLUNCH3], Year and Jurisdiction: 2009

		Eligible		**Not eligible**		**Information not available**	
Year	**Jurisdiction**	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error
2009	**National public**	132	(1.0)	156	(0.9)	145	(7.8)

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table B4.

Average Scale Scores for Science, Grade 12 by Parental Education Level, From 2 Questions [PARED], Year and Jurisdiction: 2009

Year	Jurisdiction	Did not finish high school Average scale score	Did not finish high school Standard error	Graduated high school Average scale score	Graduated high school Standard error	Graduated college Average scale score	Graduated college Standard error
2009	National public	131	(1.4)	138	(1.2)	160	(0.8)

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table B5.

Average Scale Scores for Science, Grade 12 by Race/Ethnicity Used to Report Trends, School -Reported [SDRACE], Year and Jurisdiction: 2009

		White		Black		Hispanic		Asian/Pacific Islander		American Indian/Alaska Native		Two or more races	
Year	**Jurisdiction**	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error	Average scale score	Standard Error
2009	**National public**	159	(0.7)	124	(1.3)	133	(1.3)	164	(3.3)	144	(3.7)	144	(3.9)

NOTE: Black includes African American, Hispanic includes Latino, and Pacific Islander includes Native Hawaiian. Race categories exclude Hispanic origin. Prior to 2011, students in the “two or more races” category were categorized as “unclassified”. The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Table B6.

Average Scale Scores for Science, Grade 12 by Gender [GENDER], Year and Jurisdiction: 2009

		Male		**Female**	
Year	**Jurisdiction**	Average scale score	Standard Error	Average scale score	Standard Error
2009	**National public**	152	(1.0)	146	(1.0)

NOTE: The NAEP Science scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment.

Coffman, Mitchell W. Bachelor of Arts, Louisiana State University, Spring 1987; Master of Landscape Architecture, Louisiana State University, Fall 2004; Master of Science, Spring 2005; Doctor of Education, University of Louisiana at Lafayette, Fall 2015
Major: Educational Leadership
Title of Dissertation: A National Study of the Relationship between Home Access to a Computer and Academic Performance Scores of Grade 12 U.S. Science Students: An Analysis of the 2009 NAEP Data
Dissertation Director: Dr. Robert Slater
Pages in Dissertation: 119; Words in Abstract: 325

ABSTRACT

The purpose of this dissertation was to examine the relationship between student access to a computer at home and academic achievement. The 2009 National Assessment of Educational Progress (NAEP) dataset was probed using the National Data Explorer (NDE) to investigate correlations in the subsets of SES, Parental Education, Race, and Gender as it relates to access of a home computer and improved performance scores for U.S. public school grade 12 science students. A causal-comparative approach was employed seeking clarity on the relationship between home access and performance scores. The influence of home access cannot overcome the challenges students of lower SES face. The achievement gap, or a second digital divide, for underprivileged classes of students, including minorities does not appear to contract via student access to a home computer. Nonetheless, in tests for significance, statistically significant improvement in science performance scores was reported for those having access to a computer at home compared to those not having access. Additionally, regression models reported evidence of correlations between and among subsets of controls for the demographic factors gender, race, and socioeconomic status. Variability in these correlations was high; suggesting influence from unobserved factors may have more impact upon the dependent variable. Having access to a computer at home

increases performance scores for grade 12 general science students of all races, genders and socioeconomic levels. However, the performance gap is roughly equivalent to the existing performance gap of the national average for science scores, suggesting little influence from access to a computer on academic achievement. The variability of scores reported in the regression analysis models reflects a moderate to low effect, suggesting an absence of causation. These statistical results are accurate and confirm the literature review, whereby having access to a computer at home and the predictor variables were found to have a significant impact on performance scores, although the data presented suggest computer access at home is less influential upon performance scores than poverty and its correlates.

Biographical Sketch

Mitchell Ward Coffman was born in Lafayette, Louisiana in 1965. Louisiana State University graduated him in 1987 a Bachelor of Science in Speech Communications. In 2004, Louisiana State University graduated him a Master of Landscape Architecture. In 2005, Louisiana State University graduated him a Master of Science in Environmental Planning and Management. In 2010, the University of Louisiana at Lafayette awarded him a Louisiana teaching certificate after completion of the Teacher Alternative Certification Program. In 2015, the University of Louisiana at Lafayette graduated him a Doctor of Education.