THE DIFFERENCE BETWEEN GRADE 7 FEMALE AND MALE TEST SCORES BASED ON ONE-TO-ONE TECHNOLOGY ACCESS: A CAUSAL-COMPARATIVE STUDY

by

Windy S. Hammond

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

Liberty University

2022

THE DIFFERENCE BETWEEN GRADE 7 FEMALE AND MALE TEST SCORES BASED ON ONE-TO-ONE TECHNOLOGY ACCESS: A CAUSAL-COMPARATIVE STUDY

by Windy S. Hammond

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

Liberty University, Lynchburg, VA

2022

APPROVED BY:

Jeffrey S. Savage, Ed.D., Committee Chair

Angela Y. Ford, Ed.D., Committee Member

ABSTRACT

This causal-comparative study sought to determine whether there was a relationship between the use of one-to-one technology and student achievement among female and male students in Grades 6 and 7 in public schools in South Carolina. This study adds to the body of literature that indicates academic gains occur from using one-to-one devices in classrooms and that these didactic technology tools are beneficial to all students. The current study analyzed the science and social studies achievement scores of 3,747 Grade 7 students, comparing females and males who had access to one-to-one technology to those who did not during the 2016–2017 school year. The achievement scores came from the archived scores of the South Carolina Palmetto Assessment State Standards (SCPASS) tests in science and social studies. The study resulted in a rejection of the null hypotheses in favor of the alternative hypothesis that one-to-one technology had a statistically significant influence on test scores across all samples; however, with weak effect sizes, the practical significance of these results should be explored further. Recommendations for future research include conducting additional studies in more geographical areas, grade levels, and subjects and investigating the influence of distraction while using one-to-one technology.

Keywords: active learning, digital divide, K–12, one-to-one technology, STEM, technology integration, traditional learning

Copyright Page

Dedication

Thank you to everyone for your encouragement and for supporting my progress as I traversed each stage of this journey. I could not have completed this degree without the guidance of my Lord and Savior, Jesus Christ. I kept this Bible verse in my heart throughout this endeavor: “Therefore, since we are surrounded by so great a cloud of witnesses, let us also lay aside every weight, and sin which clings so closely, and let us run with endurance the race that is set before us” (Hebrews 12:1, ESV). I especially want to thank my parents, Dr. Ed and Bonnie Sherbert for being there for me, not just as I worked to earn this degree, but for always supporting me throughout my life. You are the best parents in the world, and I love you so much. I know Memere and Pepere and my cousin Ryan are proud of me in heaven.

I also want to thank.my sister Candy, my cousins Erin and Nathan, and my niece Kendal. Thank you all for the love and support you have given me. Thank you to my doctoral tribe of friends: Angela, Amanda, Blake, Kelly, Wendy, and Emmanuel, I love you all! (And don’t forget the last slide!). Becka, Daylene, and Maria, I am blessed to call you friends. Tammy and Ashley, thank you for always being there for me. Thank you to Debbie and Claire for your friendship and expertise. Thank you to my Sunday School class (Bridgebuilders), my ladies Bible circle (Friendship), and the handbell choir. Thank you for all of your love.

To my husband Ray, you are my biggest cheerleader. You always enthusiastically believed I could do this, but I could not have done it without you. Words can never thank you enough. We are now Major and Dr. Hammond! To Grayson and Luke, you are my whole world. I hope I have made you proud and have shown you that there are no limits to what you can accomplish in life. I love you so much!

Now, you get to have your mommy back.

Acknowledgments

I sincerely want to thank my committee members, Dr. Jeffrey Savage and Dr. Angela Ford, for their expertise and support during this journey. Their advice was invaluable, and their kindness and encouragement kept me going. I am honored that they chose to work with me, and I aspire to be as professional, knowledgeable, and enjoyable to work with as they both are. Liberty is blessed to have two of the best educators and researchers on their faculty. Thank you from the bottom of my heart!

Table of Contents

List of Tables

List of Figures

List of Abbreviations

British Educational Suppliers Association (BESA)

Emergency Remote Teaching (ERT)

Federal Communications Commission (FCC)

Freedom to Learn (FTL)

Information and Computer Technology (ICT)

Information Technology (IT)

Maine Learning Technology Initiative (MLTI)

Multiple Intelligences (MI)

National Center for Education Statistics (NCES)

National Commission of Excellence in Education (NCEE)

National Science Foundation (NSF)

Randomized Control Trial (RCT)

Rubin Causal Model (RCM)

Science, Technology, Engineering, and Mathematics (STEM)

South Carolina Palmetto Assessment State Standards (SCPASS)

South Carolina State Department of Education (SCSDE)

Student Engagement Technologies (SEG)

Student in Poverty (SIP)

Technology Enhanced (TE)

United Nations Educational, Scientific, and Cultural Organization (UNESCO)

Zone of Proximal Development (ZPD)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quantitative, causal-comparative study was to determine if there are statistically significant differences between achievement scores on state-wide assessments between Grade 7 female and male students who were provided access to one-to-one technology and students who were not during the 2016-2017 school year. Chapter One provides a background for technology advancement in public schools, the social and theoretical context, and the applications of technology. The problem statement examines the scope of the recent literature on this topic. The chapter then describes the purpose of this study and its significance, before concluding with the guiding research questions and a list of key terms and their definitions.

Background

The transition from traditional learning methods, such as using pencil and paper, to learning while conducting various electronic tasks on a laptop fundamentally changes how instruction is delivered in the classroom (Zheng et al., 2016). This instructional change has also shifted the traditional focus of the information delivery system from a teacher-centered to a more student-centered or learner-centered environment. Learner-centered teaching was first introduced to pre-service teachers in the United States and United Kingdom in the 1970s (Tatnall & Davey, 2014). Using technology allows teachers to customize instruction for individual students, allows students to learn at a self-paced speed, and provides scaffolding support for students to help them achieve higher levels of performance and understanding (Kim et al., 2020; Shvarts & Bakker, 2019; Yelland & Masters, 2007). Several studies on the use of learner-centered instruction show an increase in engagement, in feelings of self-esteem, in motivation, and in academic performance, compared to more traditional methods (Greenhow et al., 2020; Lee et al., 2018).

Public school districts across the United States are rapidly adopting one-to-one technology programs, especially as the price of technology has decreased and the portability and ingenuity of devices such as laptops and smartphones have increased (Elliott-Dorans, 2018; Engelhardt et al., 2021; Lewis, 2020). One-to-one technology refers to internet-connected devices, such as laptops and computers, that are provided for every student and teacher in a classroom (Hershkovitz & Karni, 2018; Parks & Tortorelli, 2020). School districts are also consistently seeking ways to provide students with tools that help them develop 21st-century skills; technologically-advanced devices, such as laptops, can assist in this endeavor (Grundmeyer & Peters, 2016; Kim et al., 2020). School districts must make the argument to parents, teachers, and taxpayers that one-to-one technology is worth purchasing, considering that the high cost of equipping an entire school district with one-to-one devices (Grundmeyer & Peters, 2016).

Given the nationwide adoption of additional technology by school districts across the United States during the 2020 pandemic, it is imperative to investigate whether the use of one-to-one technology has any beneficial academic effects on student achievement (Brandon & Florence, 2016; Burns et al., 2020; Iivari et al., 2020; Swallow, 2015). The COVID-19 virus had unprecedent impacts on public health, economic stability, and educational endeavors in almost every country in the world (Greenhow et al., 2020). The continued and ubiquitous use of one-to-one technology means that educators and education decision-makers must remain informed and trained in current technology skills and information (Grundmeyer & Peters, 2016). Adding a one-to-one technology program affects the many moving parts of a school district, such as budgeting, personnel training, and technology maintenance (Hull & Duch, 2019; Liu et al., 2017; Topper & Lancaster, 2013). Purchasing new one-to-one devices creates increased costs that can be offset by increasing student fees, asking for community business support, and reducing the budget of print material. In addition, school districts must provide technical support to educators and training in device management and troubleshooting. One standard option to increase teacher support is by adding a technology coach to the teaching staff. Another decision is for schools to provide technology workshops during teacher training sessions (Topper & Lancaster, 2013).

The global pandemic created a shift in parental responsibilities and roles when remote learning was established (Greenhow et al., 2020; Szente, 2020). Parents were forced to help their students use one-to-one technology, understand new instructions, secure Internet access, and supervise participation while learning at home. In several studies, parents reported feeling ill-equipped to aid their children during the pandemic, citing a lack of technology knowledge (Greenhow et al., 2020; Larkin, 2014; Szente, 2020). Other studies conducted during the pandemic concluded that parents require support and guidance while helping their children use technology at home, suggesting that parents receive instructional videos on technology troubleshooting and instructions (Greenhow et al., 2020). Furthermore, there were additional stresses at home that interfered with instruction, such as family factors, a lack of Internet infrastructure, and parents' ability or inability to stay at home and supervise learning (Greenhow et al., 2020; Szente, 2020).

There should be ongoing considerations and investigations as to whether the addition of one-to-one devices provides benefits or simply creates additional distractions for students and teachers, regardless of the incremental increases in the use of technology during the pandemic (Holen et al., 2017). During the 2019-2020 school year, school districts relied on one-to-one devices more than ever before (Engelhardt et al., 2021; Gopalan et al., 2020; Greenhow et al., 2020; Szente, 2020). This study offers an essential look at whether there are any educational benefits of using one-to-one technology in schools since these mobile devices have become increasingly ubiquitous across the United States and are likely here to stay (Engelhardt et al., 2021; Greenhow et al., 2020; Johnson et al., 2014).

Historical Overview

The launch of Earth's first artificial satellite, Sputnik, in 1957 galvanized the United States into placing a call to action focused on increasing educational standards (Garcia, 2017). Americans were instantly scared into believing their youth were not as academically prepared in mathematics and science subjects as the youth of other nations, specifically the Soviet Union (Witteveen & Attewell, 2020). In its infancy, computers were used to synthesize large numbers, so computing began primarily with "number crunching" in the 1950s (Tedre et al., 2018). Educational technology during the 1950s and 1960s was focused on educational television programming. Then, in the 1960s, programming classes and computation research emerged, while educational television programming declined (Fletcher, 2019). By the 1970s, computer devices were being viewed as opportunities for students to express themselves creatively (Molnar, 1997; Saettler, 2004; Stager, 2016).

The 1980s brought about the development of the first desktop computer, and schools began purchasing them to populate computer classrooms dedicated to teaching students how to use the latest technology and software. Though the first desktop computers were limited in function compared to technological advances today, many teachers felt that they were too busy attending to other initiatives to spend time using computers in the classroom (Tatnall & Davey, 2014). In 1983, the National Commission of Excellence in Education published a report titled *A Nation at Risk*, which called upon U.S. public school districts to raise academic standards so that all students could compete on a global scale (Diamond, 2016). In the late 1990s, several singular studies investigated the bivariate relationship between computer availability and academic achievement, with mixed results. Before this time, computational research was composed of opinions, observations, and speculations rather than empirical data (Tatnall & Davey, 2014). Individual technology became more affordable to the public 10 years later, and most households possessed at least one computer (Greenhow et al., 2020). Although considered too costly of an endeavor, the suggestion that every student possess a personal laptop or computer arose in the 1970s. By the turn of the current century, this was no longer a dream but a reality (Stager, 2016).

In 2003, Maine became the first state to purchase a personal computer for every Grade 7 and Grade 8 student in every public school (Brandon & Florence, 2016; Sack, 2003; Stager, 2016). Two years earlier, the largest single implementation of one-to-one technology took place in Henrico County, Virginia, and provided laptops for the 43,000 students in the county (Mcwilliam & Dawson, 2008). As the success of these programs was heralded in the educational field, more and more states initiated their own one-to-one adoption programs. Florida implemented a program called Leveraging Laptops in 2009 and funded one-to-one laptops for students in 11 districts (Brandon & Florence, 2016; Dawson et al., 2008). In the same year, the North Carolina Learning Technology Initiative (NCLTI) purchased laptops for 13,000 students in the Tar Heel state (Brandon & Florence, 2016; Corn et al., 2012).

Despite the increase in the number of digital devices that Americans own, recent research has indicated that there continues to be a digital divide between students who have access to technology at home and in school compared to many of their peers without the same access (Santo et al., 2020; Snyder et al., 2016). This technology gap, often referred to as a “digital divide,” began in the 1990s and expanded as school districts created budgets that allowed for the purchase of technology for classroom use. The digital divide was addressed during the Obama administration with the ConnectED initiative (DeMers, 2014; Osborne & Morgan, 2016; Peel, 2015), which aimed to provide personalized learning environments connected to high-speed Internet service to 99% of American students by 2019. The Federal Communications Commission (FCC) invested two billion dollars and 10 major corporation donations in software, training, and computing equipment to fund the initiative (DeMers, 2014; Peel, 2015). In addition to providing students with personal learning environments, the ConnectED initiative sought to strengthen learning opportunities for children in low-income communities (Peel, 2015).

Introducing technology in every classroom has changed how classrooms look and function today compared to 20 years ago (Saunders et al., 2017; Vincent-Lancrin et al., 2019). However, this transition is a necessity to train future leaders and innovators and to shape a technologically-competent workforce prepared for the skills required in the 21st century (Barak, 2017; Belland et al., 2017; Holen et al., 2017). One of the most important factors to consider with these state- or district-wide programs is the cost (Larkin, 2014). In addition to equipment purchases, planning must also include teacher training, infrastructure installation and maintenance, and developing guidelines and protocols for use (Kwon et al., 2019; Vincent-Lancrin et al., 2019).

Society at Large

Many recent studies have suggested that one-to-one technology can be beneficial, especially for marginalized and female students (Campos & Castillo, 2015; Osborne & Morgan, 2016). In the past, minority students, students from low socio-economic backgrounds, and students with learning disabilities maintained less access to Internet-supported devices than their peers, thus creating the “digital divide” (Campos-Castillo, 2015; Corn et al., 2012; Osborne & Morgan, 2016; Snyder et al., 2016). Recent studies purport that female students specifically may benefit from technology use in the classroom (Breiner, 2016; Johnson & Walton, 2015; Liu et al., 2019; Simon et al., 2020; Witteveen & Attewell, 2020). Many educational experts suggest that, while using one-to-one technology, females may become more interested in science, technology, engineering, and mathematics (STEM) classes, experience increases in academic success, and may help eliminate the "leaky pipeline" in terms of the majors students pursue (Johnson & Walton, 2015; Witteveen & Attewell, 2020).

The "leaky pipeline" describes students who are interested in pursuing a career in STEM subjects but leak out of the college track and fail to graduate with a degree in science, technology, engineering, or mathematics (Ellis et al., 2016; Johnson & Walton, 2015; Witteveen & Attewell, 2020). The low number of baccalaureates in STEM subjects can be problematic for the U.S. effort to remain economically competitive. Many leaders in the United States worry that the "leaky pipeline" will cause the country to rely more upon foreign workers to populate jobs that require STEM degrees and training (Witteveen & Attewell, 2020). According to current research, females experience a disproportionate graduation rate from STEM subjects compared to males. Only 40-60% of students who begin a STEM degree graduate with one. Of those graduates, only 35% are women (Ellis et al., 2016). In a national report by the President's Council of Advisors on Science and Technology in 2012, advisors concluded that one million more STEM professionals needed to enter the workforce to maintain the country's preeminence in STEM career fields (Olson & Riordan, 2012).

Theoretical Background

Constructivist theory refers to a wide category of thought used to describe how cognitive development occurs using social processes (Barak, 2017). It is categorized under the umbrella of many related theories, such as Lev Vygotsky's (1962) sociocultural theory, Albert Bandura's

(2002) social cognitive theory, and Jean Piaget's (1952) socio-cognitive conflict theory (Huang & Liaw, 2018). The proponents of constructivist theory believe that students should learn with others who are more knowledgeable and meaningful to them, such as peers and instructors (Fernández et al., 2015; McNeil & Uttal, 2009; Xu, 2019; Yasnitsky, 2018). Constructivists posit that learning occurs through interactions with others, as new understanding begins with the help of others (Upham et al., 2014).

Constructivist theory suggests that learning should be an active process and abandons the passive view of education that considers students simply as empty vessels that need to be filled with knowledge (Lee et al., 2018). Constructivists believe that students need meaningful, active engagement while constructing new knowledge (Barak, 2017; Moll, 2014). Early researchers of constructivist theory include psychologists such as Bandura, Vygotsky, and Dewey (Huang & Liaw, 2018; Moll, 2014; Morse, 2015). Dewey believed that learning is connected to motivation, so activities and lessons should focus on students' interests. Vygotsky suggested that learners use their culture and resources to construct their knowledge (Yasnitsky, 2018). Bruner posited that learners acquire new ideas from past knowledge and that students must come back to fundamental concepts during the learning process (Cantú & Farines, 2007). The constructivist approach also provides students with opportunities to solve real-life problems (Huang & Liaw, 2018). This type of learning challenged the early U.S. educational system in which the classroom was teacher-led and students' interests were not considered (Barak, 2017).

Today, students can use one-to-one technology to simulate solving real-life problems (Yadav et al., 2016). In the form of simulations and virtual reality programs, the technology available today is vastly more sophisticated and life-like than ever before (Ruipérez-Valiente & Kim, 2020). Students can, for example, mimic dissecting an animal in a biology class using virtual reality software. Offering an augmented reality experience can drastically reduce laboratory costs and preparation while also allowing students to experience dissection, even for those who may be opposed to the activity for personal or religious reasons (Huang & Liaw, 2018).

As educational pedagogy continues to evolve, the tools educators employ also change continuously. K–12 students today are surrounded by technology, both at home and in their classrooms. In recent years, educators and educational decision-makers have faced unprecedented pressure to provide technology for student use. Understanding the impact of technology usage on assessment scores, such as one-to-one technology, is one of many concerns we must address to equip students with 21st-century skills.

Problem Statement

Prior studies have not sufficiently addressed the extent of technology's influence on students' academic achievement in K–12 public schools (Islam & Grönlund, 2016). Research on the use of laptops as a type of one-to-one technology began with tertiary students in college classrooms and is slowly being added to the extant literature on K–12 classrooms. The results of these studies can be described as mixed at best. Some studies have published results that indicate achievement increases with the use of one-to-one technology (Engelhardt et al., 2021; Harper & Milman, 2016). Other studies are varied, with some results showing academic improvement only in certain areas, such as literature or mathematics (Hull & Duch, 2019; Zheng et al., 2016). However, many studies cannot statistically provide evidence of any significant academic improvements students make when using one-to-one technology (Holen et al., 2017; Nielson et al., 2015; Patterson & Patterson, 2017). In addition, to date, there are very few longitudinal and quantitative studies that attempt to connect academic achievement with the use of technology in the classroom (Doron et al., 2019).

There are also additional components that have not been examined centrally in considerations of technology use. For example, the extant literature has suggested that specific marginalized populations may benefit from using laptops in classrooms, such as females, minorities, and students who receive special education services (Campos-Castillo, 2015; Outlay et al., 2017). Students often decide to participate in STEM classes before high school (Pinkard et al., 2017), and studies indicate that most females lose interest in technical subjects during the middle school years and that using one-to-one technology may help increase their feelings of STEM self-efficacy (Kang et al., 2019). Female students' attitudes toward technology may be related to the extent of access they have to one-to-one devices at home (Outlay et al., 2017). The problem is that the literature has not fully addressed the impact of one-to-one technology on academic achievement (Elliott-Dorans, 2018; Holen et al., 2017; Nielson et al., 2015; Patterson & Patterson, 2017).

Purpose Statement

The purpose of this causal-comparative quantitative study was to determine if there is a difference between Grade 7 scores in the areas of science and social studies between female and male students who have access to one-to-one technology and those who do not. The theory guiding this study was constructivist theory, which views technology as a socially active learning tool that increases digital literacy and academic achievement (Barak, 2017).

The independent variable for this study was the use of one-to-one technology for females and males, measured separately. The dependent variable was achievement changes between Grade 7 males and females, measured separately, in science and social studies. The dependent variable represented content knowledge of science and social studies, as reported by the South Carolina Palmetto Assessment State Standards (SCPASS) exam. The study populations consisted of two groups of students in South Carolina public middle schools: Grade 7 students who had access to one-to-one technology and Grade 7 students who did not have one-to-one technology during the 2016–2017 school year. The covariate was the Grade 6 SCPASS test scores for the sample used in the research study.

The sample for this study comprised Grade 7 female and male students enrolled in two school districts in the state of South Carolina, designated as District A and District B. One school district provided the test scores for the SCPASS exam for students who did not use one-to-one technology during the 2016–2017 school year, and the other provided the sample for students who did use one-to-one technology during the 2016–2017 school year. The researcher employed ANCOVA testing to compare the Grade 7 test scores in science and social studies between the two types of one-to-one technology use, controlling for Grade 6 scores in science and social studies.

Significance of the Study

The practical significance of this study was to benefit students, educators, parents, and all technology decision-makers in school districts across the United States. Data that indicate that students can benefit from using laptops in the classroom can be used to support the purchase of technology and its associated ongoing costs (Larkin, 2014). If students are expected to develop 21st-century skills, they should be provided with technology to assist them in their academic and social endeavors (Hull & Duch, 2019). Teachers should also be considered in discussions on the benefits of using laptops in the classroom. Many current research studies suggest that teachers are not fully prepared to use technology in the classroom and lack training in their pre-service years (Grundmeyer & Peters, 2016; Heath, 2017).

Since one-to-one technology is a relatively recent phenomenon in classrooms, there are few longitudinal studies on its effects on academic success in the current literature (Harper & Milman, 2016; Zheng et al., 2016). School districts that chose not to test students district-wide may not have reported test scores during the COVID-19 pandemic (Burns et al., 2020). Analyzing the pre-pandemic data will benefit school districts that must still decide to purchase one-to-one devices or that need quantitative data to support the ongoing costs of sustaining a technology initiative.

Empirically, studies have shown mixed results regarding the benefits of using one-to-one technology. There is a worldwide concern about its effects. For instance, in 2008, half of the population of science students in 12 high schools in Sydney, Australia, received laptops (Crook & Sharma, 2013). Three years later, researchers used multiple regression analysis to evaluate the year-end test results of both student populations—those who used laptops and those who did not. A medium effect size in the subject of physics revealed benefits in the academic success of students who received access to laptops in the classroom, compared to their peers (Crook et al., 2015).

Not all studies indicate there are advantages to using laptops in classrooms. One study conducted at a university in the Midwest reported that student grades fell by 0.05 points for classes that required students to bring laptops to class (Patterson & Patterson, 2017). Other studies described declines in test scores but could not definitively provide quantitative data to support the argument (Nielson et al., 2015; Patterson & Patterson, 2017). As reported in qualitative studies involving personal interviews, classroom teachers have expressed that they consider one-to-one technology a distraction (Doran et al., 2019; Elliott-Dorans, 2018).

The theoretical significance of this study discussed technology use as an active and socially motivating tool. Students can work collaboratively with the teacher and their peers using one-to-one technology, further enhancing learning outcomes. This also allows students to actively create and expand their knowledge, placing them in a self-directed role that is well suited for learning (Ruipérez-Valiente & Kim, 2020). Teachers can send content and assessments to students electronically and use data to drive their decision-making, all of which were beneficial to educators and students alike during the 2020 global pandemic.

Research Questions

The following research questions guided this study seeking to identify measurable academic gains for students who use technology in the classroom in the form of laptop devices. Constructivist theory provided the theoretical framework for the research questions and data collection tools.

RQ1: Is there a difference in science achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ2: Is there a difference in science achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ3: Is there a difference in social studies achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ4: Is there a difference in social studies achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

Definitions

1. *British Educational Suppliers Association (BESA)* – Supplies materials from education technology to school furniture of schools in the United Kingdom and internationally (BESA, 2016).
2. *Digital Divide* – The gap in technology accessibility between children of low socio-economic status and their peers (Osborne & Morgan, 2016).
3. *Digital Literacy* – A person's ability to use technology to communicate, evaluate, and create information (Chang, 2012).
4. *Emergency Remote Teaching (ERT)* – The description used to explain the shift toward online instructional technology during a crisis (Xie & Rice, 2021).
5. *Leaky Pipeline* – The large attrition rate of students who declare a major in STEM subjects at the beginning of their collegiate endeavors compared to the smaller percentage who graduate with STEM degrees (Johnson & Walton, 2015).
6. *Marginalized Populations* – A group of people who are excluded from society in part or in full, based on unequal power relationships that may include: racial minorities, females,

persons living in poverty, persons receiving special education services, persons receiving special needs services, persons experiencing homelessness, and persons who identify as gay, lesbian, bisexual, and transgender (Simon et al., 2020).

7. *One-to-One Technology* – This technology provides personal access to an electronic device for each student, with the intent to increase academic achievement and engagement in schools (Grundmeyer & Peters, 2016).
8. *STEM* – The term used to describe science, technology, engineering, and mathematics subjects (Breiner, 2016).
9. *Twenty-First-Century Skills* – Skills that require students to learn how to use current technology, collaborate with peers, synthesize data, report findings, and use the Internet to research information (Grundmeyer & Peters, 2016).
10. *Zone of Proximal Development (ZPD)* – The ZPD is the distance between actual developmental levels and the higher potential levels a student is working toward when guided by a tutor or a peer (Fernández et al., 2015).

CHAPTER TWO: LITERATURE REVIEW

Overview

The researcher completed a review of the literature to explore the origins of constructivist theory, its connections to learning in the 21st century, and the extant literature on learning while using one-to-one technology and on academic achievement. This chapter starts with a theoretical framework overview that discusses the major contributions to the theory of constructivism by Lev Vygotsky and Jerome Bruner. It also introduces the terms *zone of proximal development*, *scaffolding*, and *spiral curriculum*. The related literature section then addresses one-to-one technology initiatives, the 2020 global pandemic and education, high-stakes testing, and active learning using technology. Finally, the chapter concludes with a summary of the literature.

Theoretical Framework

This study was grounded in two constructivist theories: the zone of proximal development and scaffolding. Constructivist theory is a broad umbrella of thought used to describe how cognitive development occurs using social processes. Early constructivist theorists included John Dewey (1929), Jean Piaget (1952), Jerome Bruner (1961), and Lev Vygotsky (1962). Though there are many variants of constructivist theory, they all share the philosophy that learning is an active activity by which the learner constructs new knowledge (Bachtold, 2013; Huang & Liaw, 2018; Hussain et al., 2020; Hyslop-Margison & Strobel, 2008). Learning is an activity that can be performed individually or with peers' and teachers' assistance (Bachtold, 2013; Hussain et al., 2020; Huang & Liaw, 2018). Learners do not just absorb information but combine it with previously acquired knowledge to construct new knowledge (Baviskar et al., 2009; Huang & Liaw, 2018; Hyslop-Margison & Strobel, 2008). In constructivist learning, the whole is more important than the parts. This type of learning is best when a learning task is student-led, as in problem-based learning (Agarkar, 2019).

Each constructivist philosopher focused on different aspects of the theory. Lev Vygotsky (1978) was a product of his time in the transition from feudal Russia to the rise of the Soviet Union, and he focused on understanding children's abilities to learn through social interactions with others, especially their parents (Fani & Ghaemi, 2011; Holzman, 2009). John Dewey (1938), also known as a pragmatist, believed that personal knowledge is constructed through individual cognition and that the skills and knowledge students developed should be integrated into their lives as productive citizens and workers (Hyslop-Margison & Strobel, 2008). Jerome Bruner (1960) introduced the concept of problem-solving and added to the works of Vygotsky (Stapleton, 2019). Dewey (1929), Piaget (1952), and Vygotsky (1978) all maintained that students inherently have prior knowledge and experiences that will influence how they process new information (Hyslop-Margison & Strobel, 2008).

The prior knowledge students acquire can be considered "concepts" or "constructs." According to Bachtold (2013), concepts can exist on a mental or a symbolic level. A concept is a mental representation and can be comprised of facts, concepts, experiences, values, or emotions (Bachtold, 2013; Baviskar et al., 2009; Hyslop-Margison & Strobel, 2008). The concepts persist after they are taught or transform and coexist with new knowledge that is created (Bachtold, 2013). According to Hyslop-Margison and Sears (2006), these constructs are difficult to change. If the previously-known concept is presented with evidence that counters it, students may disregard the new information and "file it away." The new knowledge model becomes intelligible if the student resists changing the original concept (Hyslop-Margison & Sears, 2006). Bachtold (2013) suggested that some socio-cultural concepts are expressions that are commonsense conceptions, while students spontaneously construct others (Bachtold, 2013). According to constructivist theory, teachers can help learners become aware of the differences between prior and new knowledge, thereby creating cognitive dissonance (Baviskar et al., 2009). The constructivist teacher's role is to provide resources and relevant problems while creating an environment that is motivating to the learner and that links the resources to the student's prior knowledge (Baviskar et al., 2009). The teacher's goal is to help a student overcome the difficulties of assimilating new knowledge (Bachtold, 2013; Baviskar et al., 2009).

As opponents of constructivism point out, it is not enough to say that knowledge is constructed, as beliefs can be false or true (Siegel, 2004). Belief is intertwined with knowledge, but it must be true belief based on evidence (Hyslop-Margison & Strobel, 2008). For example, a student may have prior knowledge that two plus two equals five, but that belief is not based on truth. Modern constructivist theorists posit that there must be a restriction on the idea that students construct their knowledge and note that students cannot rediscover what scientists have already discovered (Bachtold, 2013). If the prior construct is false, the learner must apply changes to the concept and receive feedback on the validity of sources from other constructs (Baviskar et al., 2009).

Constructivism is a theory of learning and not one of curriculum design. There is confusion in the literature as to what actions constitute constructivist activities (Baviskar et al., 2009). In addition, there is distrust amongst some constructivists, who dismiss other epistemic theories (Hyslop-Margison & Strobel, 2008). A narrow view of constructivist teaching suggests that teacher-led lectures are not useful for knowledge acquisition. However, lectures can be invaluable tools if used in the proper context and when students are equipped with a high amount of prior knowledge (Hyslop-Margison & Strobel, 2008; Schwartz & Bransford, 1998).

According to the extant literature, direct, explicit teaching methods have a place in learning, and constructivist educators should not dismiss these time-honored and effective strategies (Hyslop-Margison & Strobel, 2008). As viewed through the lens of constructivism, knowledge construction is an activity of the mind and not necessarily one of the body. Some teaching methods link constructivism to hands-on activities, but no direct link exists between this teaching style and constructivist theory—or between one's teaching style and a student's preferred learning style (Bachtold, 2013; Cuevas, 2016; Pashler et al., 2008).

Lev Vygotsky

Many scholars consider Russian psychologist Lev Vygotsky be the father of constructivist theory, but it was practically unknown in education beyond the Soviet Union during his lifetime (Mattar, 2018; Moll, 2014). Vygotsky fell ill with his first bout of tuberculosis in 1920 and often spent months convalescing after an episode. Despite his poor health, Vygotsky studied the psychological development of children and published books and articles on his philosophy and findings that educators still use today (Daniels, 2017; Yasnitsky, 2018). However, writings by Vygotsky were banned in Russia until the 1950s and were only translated into English in the 1960s (Moll, 2014; Newman & Latifi, 2021; Yasnitsky, 2018).

Vygotsky based his work on Alfred Adler, Friedrich Nietzsche, and Karl Marx (Yasnitsky, 2018). One of his earlier professions was teaching minimally educated elementary school teachers. Although he was never formally trained in research methods, Vygotsky eventually became head of the Cabinet of Psychology at the Gomel Pedagogical Technikum. While there, he conducted memory research and interview-based studies on students' mental attitudes (Yasnitsky, 2018). Vygotsky came to believe that people shape their nature through the mediation of others, and in the ways they use their culture and resources (Agarkar, 2019;

Daniels, 2017; Fani & Ghaemi, 2011; Newman & Latifi, 2021). Through his studies, Vygotsky explained that cognitive processes appear first at the social level, and are then internalized and transformed into unique ways of thinking (Fernández et al., 2015; Vygotsky, 1962).

Although Vygotsky has been ranked among the 100 most referenced psychologists, critics of the Vygotskian approach point out that his work was never discussed publicly during his lifetime and that his ideas were based on theories borrowed from the West (Holzman, 2009; Yasnitsky, 2018). There may also have been problems associated with translations of his studies, with heavy editing by Vygotsky's former colleagues of some of his published works (Newman & Latifi, 20201). Lastly, Vygotsky's theory of using psychological tools may neglect real-world complexities by simplifying the learning process (Yasnitsky, 2018).

Vygotsky and Tools

Vygotsky and his colleagues investigated how children use various "cultural instruments" in their attempt to understand human development. These instruments, or tools, can be psychological tools or concrete tools, such as memory cards (Yasnitsky, 2018). Vygotsky posited that it is not the tool itself that is vital for thought development and learning, but the meaning encoded in the tool. The type of tool does not matter, as long as the meaning is retained (Daniels, 2017). The Vygotskian approach holds that tools can mediate human activity. The integration of new tools into any environment has the power to transform activity (Zheng et al., 2016).

The subject of mathematics can be viewed over human history as a series of interconnected tools. Examples of tangible and visual tools that mathematicians have used over the centuries include pebbles, rods, rulers, abaci, calculators, and computers (Volkov & Freiman, 2019). Educators today continue to use the theoretical frameworks Vygotsky developed and can argue that one-to-one technology is a Vygotskian tool from a theory developed over 100 years ago. The personal computing device is an important didactical tool for all educational levels, from pre-school to the university.

Zone of Proximal Development

Vygotsky is also known for his theory of the zone of proximal development (ZPD). Though not developed fully during the psychologist's lifetime, the theory includes functions that are not yet matured. Vygotsky did not live long enough to propose a specific methodology with the use of ZPD (Fani & Ghaemi, 2011). An educational admirer of Vygotsky, Jerome Bruner, later developed ZPD into a theory of scaffolding (Upham et al., 2014; Walshaw, 2017). Vygotsky presupposed that the ZPD was the distance between independent problem-solving and potential developmental levels when guided by a more capable person (Horner, 2017; Vygotsky 1978). The zone of proximal development refers to an activity in which instructional learning leads to cognitive development and is generally seen as opposing the once-popular Piagetian concept of child development (Newman & Latifi, 2021).

The Vygotskian approach emphasizes the importance of using collaboration in learning, and the ZPD may be used as a tool for understanding the process of knowledge creation using cooperative learning (Fani & Ghaemi, 2011; Newman & Latifi, 2021). The use of cooperative learning was a common Marxist ideology during Vygotsky's lifetime after the fall of the czar. During this period of Soviet history, socialism was a valued part of society, and sharing and cooperation were encouraged (Fani & Ghaemi, 2011). As a product of his time, it is not surprising that Vygotsky placed high importance on the use of cooperative learning in his philosophy.

In contrast to academic measures that focus on the actual, current level of knowledge acquisition in a student, Vygotsky used the ZPD as an indicator of a student's anticipated future progress with the help of a teacher or a more knowledgeable peer (Yasnitsky, 2018). Vygotsky was opposed to the psychometric-based testing of students in Russian schools and argued that the use of the new theory of the Intelligence Quotient (IQ) should not be used to determine a student's cognitive level because it is a static measurement (Fani & Ghaemi, 2011; Vygotsky, 1978). Collaboration between a student and a more knowledgeable person can be verbal or nonverbal (Newman & Latifi, 2021). The ZPD is best when it is tailored to individual student needs and interests and when it is eventually withdrawn (Fani & Ghaemi, 2011).

Jerome Bruner

Jerome Bruner was one of the best-known and influential psychologists of the 20th century. He served in an intelligence post during World War II before earning a doctorate in 1941 from Harvard University, where he became a faculty member in 1945 (Greenfield, 2016; Smorti, 2019). Bruner is credited for being a member of a pioneering group of philosophers who encouraged educators to introduce problem-solving into their classrooms. Bruner was interested in how people think and reason, a shift in the educational aims of the early 1900s (Smorti, 2019; Stapleton, 2019). He sought to discover how the constructive relationship between an individual and their world functions (Xu, 2019).

Bruner was interested in intergenerational transmission and the transcendence of culture (Upham et al., 2014). Having been born blind and remaining so for his first 2 years, Bruner described a visual world he created inside his mind to cope with his loss and then sudden acquisition of vision (Greenfield, 2016). This creative cognitive development may explain his interest in the study of perception that ushered in a cognitive revolution when he published *A Study of Thinking* in 1956 (Greenfield, 2016; Smorti, 2019). Studying how rats behave after electric shock treatment, Bruner developed a cognitive theory that viewed perception as an internal process that could be influenced by beliefs, motivations, and values (Smorti, 2019). He believed that perception is a bottom-up process controlled by the senses and a top-down process that can be controlled by the mind (Greenfield, 2016).

Bruner and Education

Bruner's studies on childhood development influenced researchers on educational practices (Stapleton & Stefaniak, 2019; Xu, 2019). Bruner first began studying children at Oxford University and wanted to understand how children viewed their world. In one of his earlier works, he studied how mothers engaged with their infants and observed them encouraging their babies to babble. Babbling, Bruner believed, was an initial formation of sounds that developed into words (Greenfield, 2016). Building on Vygotsky's ideas, he believed that children learn best through interactions with others at a higher developmental level than that of the learner. Bruner proposed that the learner gradually develops new understandings with the help of those who are more knowledgeable (Greenfield, 2016).

Spiral Curriculum

Bruner opposed the concept that children needed to be at certain age stages to be ready to learn (Chaudhary & Pillai, 2019). His theory, called a "spiral curriculum," proposed that students should be introduced to concepts early on, in the young grades, and then continue to revisit the same topic several more times, increasing in complexity each time so that their old learning reinforces the new ideas as they traverse through school (Cantú & Farines, 2007; Gibbs, 2014). For example, fourth-graders in South Carolina are introduced to the parts that make up the atom: electrons, protons, and neutrons. By the 11th grade, students use their prior atomic knowledge to create Lewis electron dot structures, a much more complex task. Bruner believed that students should be introduced to concepts early in life to practice developing deeper understandings repeatedly (Chen et al., 2019). The Brunerian spiral expects teachers to engage students with the same concepts to which they were previously introduced, but critics argue that the reintroduction and building upon prior knowledge may not happen fast enough (Gibbs, 2014). The premise is that if the student does not learn the concept during the first cycle, they will pick it up in subsequent cycles. Each learning cycle is brief, so students can see results quickly, which aids in maintaining high levels of motivation (Jaime et al., 2016).

Additional critics of Bruner's spiral curriculum believe that his hypothesis neglected any consideration of students' experiences and interests, whether a student was ready for the task, the difficulties in teaching and learning with inquiry methods, and the lack of teacher preparation (Deng, 2004; Gibbs, 2014). They have even criticized the genesis of the theory. In 1960, Bruner was asked to chair a conference of scholars from many disciplines to redesign the curriculum in U.S. schools. The resulting ideas and decisions from the conference were later documented and included in his book *The Process of Education* (Bruner, 1960), which had a direct impact on educational policy formation that exists today. The major complaint stemming from the educational reform ideas developed at the conference was that no single professional educator was invited to participate (Gibbs, 2014).

Bruner and the Use of Concrete Materials

Bruner reinforced the idea that learning is an active process and that the learner can construct new knowledge from prior knowledge and from exploration of the world around them. He saw a general progression for a student of any age learning a novel concept and believed that conceptual development occurs by internalizing the environment. In his view, the process of learning new concepts happens in three stages: learners act on concrete objects, imagine forming concrete constructions, and adopt symbolic notations (Bruner, 1966; Chaudhary & Pillai, 2019;

McNeil & Uttal, 2009). The use of concrete materials, such as manipulatives, models, and computing devices, can aid in the cognitive acquisition of new concepts. However, Bruner and others (Bruner 1966; McNeil & Uttal, 2009) believed that teachers should be methodical in pointing out connections between the constructs and abstract concepts the students learned. Bruner believed that a teacher's organization and direction were of the utmost importance in providing concrete materials for educational gains (Bruner, 1966). According to Bruner, students may need to experience several concrete examples before moving to general abstract concepts; however, other educators suggest that students may struggle moving past concrete materials despite being introduced to many examples (McNeil & Uttal, 2009). Computer manipulatives can provide the ideal level of guidance and direction for students, as they can be programmed to allow specific actions and block others (Sarama & Clements, 2009). However, the use of computers is not a panacea, and scholars have argued that cognitive development only occurs when students themselves direct and regulate their activity. In many cases, however, students handle concrete materials using teacher-designed rules (Gravemeijer, 2002).

Bruner believed that the use of symbols helps construct thought through activity (Bruner 1966; Chaudhary & Pillai, 2019). This notion contributed to the development of a computer designed to be used by people of all ages. Alan Kay, a key developer for Macintosh, credited his design of the Macintosh computer to the influence of Bruner's ideas of representing information through actions, icons, and symbols. This theory inspired Kay to use icons to enable users to perform functions on an abstract set of symbols, which later became the foundation of the Macintosh interface (Greenfield, 2016).

Scaffolding

The use of scaffolding, a major component of constructivist theory, can be used to explain how teachers use technological tools to provide students with support that allows them to consistently add newly acquired knowledge to prior knowledge (Huang & Liaw, 2018; Shvarts & Bakker, 2019). In the literature, scaffolding is often viewed through the lens of Vygotsky's ZPD. Based on Vygotsky's work, Bruner first developed the term "scaffolding" as a faculty member at Oxford as he studied the conversations between moms and children (Grazzani & Brockmeier, 2019). Bruner explained, "[i]n such instances, mothers most often see their role as supporting the child in achieving the intended outcome, entering only to assist or reciprocate or 'scaffold' the action" (Bruner, 1975, p. 12). According to Bruner and his colleagues, there are six types of support that an adult can provide a student: recruiting the student's interest, maintaining direction, simplifying tasks, highlighting critical aspects of a task, controlling frustration, demonstrating the solution pathway (Fernández et al., 2015; Upham et al., 2014; Wood et al., 1976). These tasks are considered facilitator-focused, as the instructor guides the learner through the problem-solving process (Upham et al., 2014).

Over the years, other philosophers have developed a different approach to scaffolding. Drew Appleby, Professor Emeritus at Purdue University, re-examined the types of support Bruner developed and adopted a more learner-centered approach to scaffolding (Upham et al., 2014). Appleby suggested that, for scaffolding to be successful, students must take ownership of the learning event. The task must be appropriate, structured, and solved jointly. The learner should gradually take responsibility for their progress (Appleby, 1986; Upham et al., 2014). Today, software developers use scaffolding to assist students by automatically advancing to new material when they have shown mastery of the current material (Barak, 2017; Upham et al., 2014).

Computers can be used to provide scaffolding support to the learner. As students generate solutions to complex programs, goals, and tasks, one-to-one devices provide helpful added and fading support (Belland et al., 2017; Belland et al., 2018). The use of blended technology, such as a flipped classroom model, uses computers and software tools as scaffolding mechanisms (González-Estrada & Cosmes, 2019). The visualization and modeling capabilities in software tools have helped students in various subject matters (Upham et al., 2014). Computers can support and reinforce concepts that students have previously learned. In addition, learning can occur at the student's own pace to achieve individualized goals, helping them generate skills needed to contribute to a technology-rich workforce in the 21st century (González-Estrada & Cosmes, 2019).

Related Literature

Twenty-First-Century Skills

By 2028, 454 billion dollars of the U.S. economy could be at risk if employers cannot find qualified workers who possess critical 21st-century skills (Giffi et al., 2018). Emerging technologies are shaping our world and transforming our lives at a rapid pace. Technologies like artificial intelligence (AI), nanotechnology, driverless vehicles, and robots increasingly impact our daily life (Lewis, 2020). The term "21st-century skills" refers to a generic set of skills needed to help workers in a world full of technology (Lewis, 2020). The United States is in the midst of a fourth industrial revolution that demands new skills and ways of thinking for employees to be successful in the 21st-century workplace (Flowers, 2018; Lewis, 2020).

The invention of the steam engine is credited for having ushered in the first industrial revolution, followed by mass production and the use of assembly lines in the second (Lewis, 2020). The third revolution introduced computers and created a digital revolution (Elayyan, 2021). Due to additional increases in technology, today the lines are blurred between the physical, biological, and digital worlds, and this has ushered in what some see as a new, fourth industrial revolution (Elayyan, 2021; Flowers, 2018; Lewis, 2020). As cited from a survey of 400 U.S. manufacturers, the top five skills needed today are computer skills, programming skills, the ability to work with tools and technology, and critical thinking skills (Giffi et al., 2018; Lewis, 2020). Tasks that AI and robots cannot do, like critical thinking and decision-making, are also as important as the required technical skills (Lewis, 2020). The technological shift caused by this fourth revolution also affects learning and education, and schools must match their curricula with the skills needed for 21st-century employment (Elayyan, 2021; Kocdar et al., 2021).

One-to-One Initiative History

The use of one-to-one technology began in the early 1990s. By the year 2000, there were 1,000 individual public K-12 schools in the United States consistently using one-to-one technology (Holen et al., 2017). The "Anytime, Anywhere" technology initiative helped 53 public and private elementary, middle, and high schools acquire laptops and Microsoft office tools (Oliver & Corn, 2008). Administrators reported that the desire was for every student to possess a laptop but cited various constraints that would not allow this vision to materialize. Ultimately, 46% of schools adopted a dispersed model, in which laptops were supplied throughout the school, but not for every student (McLay, 1998). Then, in 2003, the first statewide purchase of laptops for every public-school student was planned and completed in Maine (Sack, 2003; Zheng et al., 2016).

The computer's ability to produce learning and knowledge distinguishes it from earlier technological devices, like radios and television (Zheng et al., 2016). When one-to-one technology devices began to trickle into various classrooms across the United States, they were used for different purposes than those of today. For example, web browsing was a widely popular option students used initially, as it was a faster way to research information than taking an entire class on a library trip (Harper & Milman, 2016; Lowther et al., 2012). Continued technological advancements in computers also helped students express themselves in unique and alternate ways than with pen, paper, and crayons (Björkvall & Engblom, 2010).

South Carolina adopted a small laptop program in Beaufort County in 1997 to purchase 300 laptops (Morse, 2015). This implementation was a few years ahead of other one-to-one initiatives adopted worldwide. For example, Henrico County, Virginia, provided laptops to every student in Grades 7 and 8 in 2002 (Semas, 2001). The Fullerton, California, school district purchased laptops for students in Grades 3 through 7 in 2005. By 2008, approximately 14,000 schools in the United States had purchased one-to-one technology for every student (Islam & Grönlund, 2016). A six-week one-to-one pilot program in Birmingham, Alabama, provided 15,000 laptops to students. Administrators voiced their opinion that the initiative was delivered faster than the infrastructure set up in every school. The laptops were of low quality, and 70% of them had technical problems within the first six months of use (Hockly, 2017).

A one-to-one laptop initiative during the 2006-2007 school year in one anonymous American public school saw the excessive use of instant messaging among students and the ability to video chat, which took educators and administrators by surprise. The added distractions also concerned parents who were blindsided by the school-owned machines that came home with their children, with ways to communicate with peers they had not encountered before and were not prepared to deal with. After weeks-long discussions between parents and the school, it was ultimately decided that the messaging system should be removed from the laptops, citing an exceptional amount of distraction both in the home and classroom (Levinson, 2010). The extant literature continues to report mixed results from using one-to-one technology in the classroom.

Positive Academic Outcomes from Using One-to-One Technology

Many studies report positive correlations between academic achievement and one-to-one technology use (Ertmer & Ottenbreit-Leftwich, 2010; Harper & Milman, 2016; Oliver & Corn, 2008). Studies of one-to-one technology initiatives have incorporated qualitative and quantitative data (Bas, 2016; Blau et al., 2015; Zheng et al., 2016). In an early study at the University of Michigan, researchers reported that the use of computers improved class performance by one-half of a standard deviation (Kulik & Kulik, 1991). The Maine Learning Technology Initiative (MLTI) in 2002, as well as the Michigan-supported Freedom to Learn (FTL) initiative launched the same year, found that students who used laptops to complete coursework performed higher than their peers in the control group, according to research conducted after students began using one-to-one technology in classrooms (Crook et al., 2015).

In addition to the academic gains researchers have reported, studies also cite the many positive non-academic outcomes students experience when using one-to-one technology. Computers can improve productivity and help students stay organized (Heath, 2017; Higgins & BuShell, 2018; Kwon et al., 2019; Patterson & Patterson, 2017). They empower students to learn independently through laptop use and to direct their inquiry using one-to-one technology, more than traditional teacher-led teaching strategies (Harper & Milman, 2016; Howard et al., 2015). Using one-to-one can increase student motivation through interactive teaching methods, and students can access up-to-date information (Hall et al., 2021). The use of laptops also enables students to access Internet data quickly and efficiently. These electronic devices allow teachers to facilitate inquiry in many locations, including outside the classroom (Kwon et al., 2019).

Additionally, one-to-one technology can create communication avenues using a variety of platforms and programs, such as email, video creation websites, and document sharing services (Ruipérez-Valiente & Kim, 2020). Laptops are also much less costly to own, thanks to the increasing growth and demand over the past decade (Engelhardt et al., 2021; Harper & Milman, 2016; Kwon et al., 2019). Ertmer and Ottenbreit-Leftwich (2010) insisted that technology is not just a supplemental tool used in the classroom today, but essential to enhancing student learning outcomes. However, other research articles have hesitated to proclaim the virtues of technology use in the classroom, citing the lack of consistent outcome data, teachers' inability to create meaningful lessons using technology, and the distractions that come with using one-to-one technology (Liu et al., 2017).

Negative Academic Outcomes Using One-to-One Technology

Some research in the extant literature has not established positive correlations between one-to-one technology and student achievement (Larkin & Finger, 2011). One study conducted at a university in the Midwest reported that student grades fell by 0.05 points for classes that required students to bring laptops (Patterson & Patterson, 2017). Other studies described declines in test scores but could not definitively provide quantitative data to support this claim (Nielson et al., 2015; Patterson & Patterson, 2017). As reported in qualitative studies involving personal interviews, classroom teachers have expressed that they consider one-to-one technology a distraction (Doron et al., 2019). Some school districts have thus completely abandoned their one-to-one technology programs over time (Hershkovitz & Karni, 2018).

Weston and Bain (2010) suggested that there are diminished learning and achievement outcomes across all schools, districts, and states with the continued use of one-to-one. The researchers theorized that the "uninspired" use of technology may be to blame when teachers use software tools as only presentation tools or include distractions in lesson plans like games or social media (Weston & Bain, 2010). In a study at Michigan State University, researchers concluded that there were adverse effects associated with overall college performance for students who did not own a laptop (Reisdorf et al., 2020).

Inconclusive Academic Outcomes from Using One-to-One Technology

Many research studies to date, with well-developed theoretical frameworks and research designs, have failed to report statistically significant results (Sung et al., 2016). Crook et al. (2015) explained that "[a]mong the various extant literature, the findings regarding the impact of one-to-one laptops on student attainment are inconclusive and inconsistent" (p. 275). The theory behind these mixed results may relate to teacher pedagogy in the classroom (Kwon et al., 2019). Researchers found that teachers tend to return to traditional teaching practices when they are frustrated or confused by new technology and fail to seek help for the dilemma. Many educators confess that they feel uncomfortable combining traditional teaching methods with devices such as laptops or iPads (Doron et al., 2019; Kwon et al., 2019; Nielsen et al., 2015). Other studies revealed both positive and negative correlations in the use of technology. A European commission analyzed the results of 31 one-to-one technology initiatives involving 47,000 schools, and almost all of the studies reported increases in student motivation with laptops. The same studies were inconclusive regarding the results of student learning using technology (Crook et al., 2015).

Another important point is that teachers use technology to accomplish different objectives and employ it for varying lengths of time, so studying their impact on grades or evaluations can be problematic. For example, according to Zucker and Hug (2008), mathematics teachers tend to use technology for drills and practice, history teachers for research, and English teachers for writing assignments (Holen et al., 2017). The activities also differ from classroom to classroom and grade to grade. Some educators use technology for drills and practice, and others use it to develop “games” to enhance learning (Ruipérez-Valiente & Kim, 2020).

Laptops in Tertiary Education

Lectures using the Socratic method have been utilized in universities since they were first founded in Europe over 900 years ago (Freeman et al., 2014; Kirley, 2015). The problem is that instructors often struggle to generate and maintain student attention, especially in large university classroom settings (Aguilar-Roca et al., 2012; Cakiroglu et al., 2018). The use of one-to-one technology in collegiate classrooms has had a controversial history. The first type of Student Engagement Technology (SET) brought into college classrooms was in devices that used radio signals and could be operated remotely and individually. One of those devices, known as “clickers,” allows students to answer questions by pushing a key on the device (Nagel & Lindsey, 2018). Using clickers has caused minimal changes to the classroom, has allowed students to compare their perceived knowledge with that of their peers, and can be used to take attendance and to complete surveys (Kirley, 2015; Nagel & Lindsey, 2018).

College classrooms began to mirror the societal trajectory of the rising use of mobile devices, which are part of daily communication today (Kirley, 2015). A study conducted at the United States Military Academy in 2014 indicated that 90% of professors and 57% of students believed that laptops enhanced learning (Carter et al., 2017). By 2016, 88-99% of undergraduate students reported owning laptops but used them for varying tasks (Mueller & Oppenheimer, 2016). There is more evidence in the literature, both positive and negative, on the academic effects of using one-to-one technology in collegiate classrooms compared to the effects in K–12 classrooms (Elliott-Dorans, 2018; Snyder et al., 2016). This phenomenon may be explained by observing a more extended history of technology in collegiate classrooms compared to classrooms in grades K–12. Even before the pandemic, online learning was more common in higher education classrooms than in K-12 (Xie & Rice, 2021).

As the use of one-to-one technology became more and more ubiquitous, colleges and researchers began to question the benefits of its use in higher education (Carter et al., 2017; Ferreira, 2012; Maxwell, 2007). Some colleges began requiring undergraduates to own laptops (MSU, n.d.). In addition to studies relating academic achievement to the use of one-to-one in college classrooms, some have questioned the use of these devices for taking notes. College students often take notes using a personal laptop, believing that typing what they hear from the professor is more efficient than writing notes using pencil and paper (Carter et al., 2017). The act of notetaking is a cognitively demanding process that requires a student to actively listen to information and then transcribe their understanding in a short amount of time (Mueller & Oppenheimer, 2016). Several studies have challenged the use of laptops for note-taking, citing that student performance on academic assignments is lower using technology than when they do not (Carter et al., 2017; Mueller & Oppenheimer, 2016). One study reported that computer usage lowered final exam performance by one-fifth of a standard deviation for students who used the technology compared to peers who did not use one-to-one (Carter et al., 2017). A similar study, conducted in 2014, revealed that students who hand-wrote their notes had better conceptual understanding than students who typed their notes on their laptops (Mueller & Oppenheimer, 2016).

Professors have also expressed dissatisfaction with students using laptops due to the distracting nature of the technology (Aguilar-Roca et al., 2012). A large body of work has revealed the distraction factor that communication technology can possess in classrooms (Reisdorf et al., 2020). Laptops provide tempting portals of entry into the digital world, where students may choose to focus their attention on other coursework, communicate with friends via social networks, or play games instead of focusing on classroom material (Aguilar-Roca et al., 2012; Carter et al., 2017; Maxwell, 2007). One professor adopted a "lids down" policy and banned the use of laptops in the classroom completely (Aguilar-Roca et al., 2012). In the same university, other professors believed that their students should be considered as adults and that banning laptops was too parental and controlling (Maxwell, 2007). Several studies quantitatively recorded student actions in the classroom using laptops. Students tended to use their laptops and the Internet to surf the web, check email, and chat with friends rather than to focus on classroom instruction (Ferreira, 2012; Howard et al., 2015).

Additional studies have focused on specific groups of students and how technology impacted their attention, focus, and academic success at their university. Minority groups may benefit from one-to-one technology based on collegiate studies of these students (Johnson & Walton, 2015; Snyder et al., 2016). Many colleges offer financial aid to those students who cannot afford a laptop (Reisdorf et al., 2020). Some universities have taken technology ownership further and provided each incoming first-year student with a laptop. A western Pennsylvania university reported the students' positive attitudes and a diminished digital divide between genders when every student was issued a laptop (Finn & Inman, 2004).

Laptop Adoptions Worldwide

Decreasing costs in computer manufacturing have allowed for one-to-one initiatives to increase globally (Hockly, 2017). Studies have investigated worldwide concerns about the effects of one-to-one technology since 1990 (Islam & Grönlund, 2016). In Europe, Scotland purchased one-to-one technology for two schools in 2000 and provided educator training before the integration process began (Nielsen et al., 2015). In 2012, Sweden provided one-to-one technology to students in 200 out of 209 municipalities (Islam & Grönlund, 2016). The One Laptop Per Child (OLPC) initiative, launched in 2005, was an American non-profit initiative with financial backing from companies like Google, eBay, Nortel, and News Corporation. The project's task was to provide low-cost laptop computers to students in some of the poorest countries in the world, in order to address social inequities. The initiative grew to provide laptops to students in all primary schools within the first 2 years and now manages over 1,000,000 devices (Hockly, 2017; Osimani et al., 2019).

Although many one-to-one initiatives were laudable in the early 21st century, significant obstacles have been hard to overcome or predict. The OLPC initiative sent 290,000 laptops to Peru in 2007. However, the country experienced infrastructure problems and reported that Internet and electricity access was not dependable. In Portugal, a 2008 laptop initiative distributed a million laptops to students but came to a dead-end due to a lack of adequate teacher training and ineffective learning materials (Hockly, 2017). Also, in 2008, half of the population of science students in 12 high schools in Sydney, Australia, received laptops (Crook & Sharma, 2013). Three years later, researchers used multiple regression analysis to evaluate the year-end test results for both student populations—those who used laptops and those who did not. A medium effect size in physics revealed benefits to the academic success of students who received access to laptops in the classroom compared to their peers (Crook et al., 2015).

Barriers to the Implementation of One-to-One Technology Programs

In several longitudinal qualitative studies, teachers have indicated many barriers to technology implementation, such as Internet connectivity problems, a lack of training, equipment failure, and challenges involved in keeping students engaged (Barak, 2016; Nielsen et al., 2015). Educating students in the 21st-century requires teachers to thrive in a decentralized environment by providing opportunities for students to generate and manage data, collaborate and communicate digitally, and explore new and cutting-edge technology (Barak, 2017; Grundmeyer & Peters, 2016). There is also continuous change inherent in using technology; new knowledge is constantly being added, and old knowledge becomes obsolete (Cantú & Farines, 2007). Several studies have indicated that the more supportive school administrators are of technology inclusion and teacher self-efficacy and training, the more likely an educator is to use the devices provided in his or her classrooms. The extent of a leaders' support of one-to-one technology can predict a teacher's use of the technology (Dexter & Richardson, 2020; Kwon et al., 2019).

One of the most cited barriers to implementing one-to-one technology is a lack of teacher training in pre-service years (Barak, 2016; Blau et al., 2015; Grundmeyer & Peters, 2016). Lacking digital wisdom creates an enormous barrier for teachers to overcome and can create enough of a challenge that a teacher simply abandons using the available technology in his or her school (Blau et al., 2015; Hershkovitz & Karni, 2018; Kwon et al., 2019). The use of technology may also be tied to a teacher's pedagogical beliefs. Several studies have brought forth evidence that teachers' feelings of technology self-efficacy predicted the level of integration in their classrooms (Kwon et al., 2019). Self-efficacy, a theory developed by Alfred Bandura, is a subjective judgment of what someone can do with their skills (Kwon et al., 2019). If a teacher believes that technology can be used to seek and create information, he or she is more likely to implement it in the classroom (Hershkovitz & Karni, 2018). Teachers develop self-efficacy from previous successes or failures, peer educators' successes and failures, suggestions from others, and feelings of anxiety or stress toward a task (Kwon et al., 2019). The second year of technology adoption seemed to be a turning point for some teachers and schools when the initial excitement of adding technology wears off (Swallow, 2015). Schools must also consider the additional costs of one-to-one initiatives, such as supporting network infrastructure, cyber safety, professional development, and equipment maintenance (Nielsen et al., 2015).

An additional consideration worth mentioning is that school districts should consider carefully how to implement a large technology initiative. Many schools report positive results when they use a long-term approach to implement a technology initiative (Huffman et al., 2003). Several studies site having significant problems with implementing and using the new technology based on hasty decisions and a lack of research made before installation (Hockly, 2017). It has been said that change is a process, not an event (Huffman et al., 2003). Quick decisions to adopt one-to-one technology existed even before the pandemic; however, the pandemic did not slow school districts' one-to-one adoption. Many school districts scrambled to provide one-to-one technology for every student as schools began to be shut down during the global pandemic (Gandolfi et al., 2021).

Global Pandemic

The COVID-19 pandemic created technology access inequities worldwide (Gandolfi et al., 2021). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) reported that 1.5 billion students in 188 countries were affected by school closures during the

COVID-19 outbreak. In response to closing schools, educators were forced to teach electronically. Emergency Remote Teaching (ERT) emerged to describe the change in instructional technology during the pandemic (Xie & Rice, 2021). Educational technology's original aim was to support teachers' roles and tasks online. Over time, and accelerated through the pandemic, technology became more student-centered in design (Istenič, 2021; Volkov & Freiman, 2019). Teachers were forced to adjust syllabi, assessments, feedback, and content to accommodate the delivery of long-distance instruction (Istenič, 2021; Xie & Rice, 2021). The rapid and unsystematic implementation meant differences in the set-up and delivery of online instruction in every school district and state in the United States (Istenič, 2021; Levinson, 2010).

By March 26, 2020, over 1,000 colleges and universities in the United States forced students to learn online. These institutions of higher learning spent years building up their technological infrastructures and, therefore, were able to transition to eLearning more smoothly than schools at the K–12 levels (Engelhardt et al., 2021). Colleges have now reopened their doors, and many researchers are focusing on the effects that remote instruction has had on the academic outcomes of many students, including minorities, first-generation college students, and women (Engelhardt et al., 2021; Harper & Milman, 2016; Middleton, 2020).

There have been many times when wars, weather, and the political climate forced schools to close. Millions of children lost years of education due to World War II, and one-third of the students in New Orleans were held back a grade after the devastation of Hurricane Katrina (MacGillis, 2020). E-learning has been able to fill the gap when disaster forces schools to close today (Lieberman, 2020). After the pandemic ceases to force students to learn remotely, it will take decades to determine what and how much learning was lost.

High-Stakes Testing

Today, the 21st century is perceived as an era in testing reform based on up-to-date technology and federally mandated high-stakes testing in schools (Barak, 2017; Hockly, 2017; Petrilli, 2017). Widespread adoption of the Common Core State Standards (CCSS) promoted an increased focus on critical thinking skills (Belland et al., 2017; Petrilli, 2017; Porter et al., 2011). The creation of the CCSS was an attempt to create one national curriculum that encompassed shared expectations and placed a greater focus on achievement than the typical state standards (Porter et al., 2011). These new standards were more rigorous than the previous ones, and policymakers and researchers posited that by using CCSS, student achievement outcomes would improve (Blazar et al., 2020). Although the U.S. Department of Education was not directly involved, adopting a common set of standards was tied to the Race to the Top initiative, including access to 350 million dollars in funds (Porter et al., 2011). The argument supporting the adoption of this new curriculum suggested that there would be improved efficiency in all 50 states using the same standards and that assessments could be delivered electronically, which would be more engaging to students (Porter et al., 2011).

Proponents of this change embraced the focus on test scores, praising their objectivity, accuracy, and reliability (Smith, 2017). However, high-stakes testing places pressure on public schools to produce top scores on standardized tests (Parkhouse et al., 2021; Smith, 2017). Many argue that teaching and learning today can resemble a production assembly line when the focus is largely on achievement (Boyles, 2020). Accountability in education also increased and linked student achievement to test scores and teacher evaluations (Smith, 2017). Although tens of millions of U.S. students take standardized tests annually, no stakes or consequences motivate them to excel in these tests. It is the school districts and other stakeholders, such as parents and community leaders, who use the scores for accountability metrics (Van Moere & Hanlon, 2020).

Active Learning

Active learning is considered to be any activity that does not restrict participation to reading and listening in a solitary environment. Students take agency and construct their learning when using active learning (Brod, 2021). Activities using active learning can include peer tutoring, the use of technology, collaboration, and conducting experiments (Kirley, 2015). Active learning has been placed in the same umbrella of philosophy as problem-based learning (PBL), sometimes referred to as inquiry-based learning (Brod, 2021). PBL uses scaffolding provided by the teacher or computer tools and has been reported to positively affect student outcomes (Belland et al., 2018). However, PBL aims not to increase academic achievement and content knowledge but to increase students' problem-solving skills (Agarkar, 2019; Elayyan, 2021). Students engage in real-world activities using PBL, which is vastly different from the direct teaching method.

In one meta-analysis of 225 studies of introductory college STEM classes, researchers gathered academic achievement scores of students who learned using the active approach and others using the traditional learning style (Freeman et al., 2014). The researchers reported that exam scores rose by 6% for those students who used active learning and predicted that the odds ratio of failing a traditional lecture class was 1.95 compared to the active learning classes (Freeman et al., 2014). Freeman et al. (2014) claimed that active learning leads to increases in exam performance at the collegiate level (Lombardi et al., 2021). The relationship between students' agency beliefs and task performance is believed to increase from elementary to secondary school (Brod, 2021). A recent study showed that the benefits of giving learners control over their learning may begin as early as age six (Ruggeri et al., 2019). Using active learning in early grades could help reduce achievement gaps and empower underrepresented groups to consider careers in STEM (Brod, 2021). Using active learning as opposed to the traditional “teaching by telling” method may help solve part of the problem with the “leaky pipeline” (Freeman et al., 2014). Active learning may help overall student performance in STEM classes (Brod, 2021). Specifically, evidence suggests that using active learning may provide more equitable outcomes for unrepresented students (Ballen et al., 2017).

The Leaky Pipeline

The use of technology may improve the “leaky pipeline” in STEM education for females. The number of females who indicate their desire to major in science, technology, engineering, and mathematical (STEM) subjects decreases beginning in middle school through the post-secondary grades (Grundmeyer & Peters, 2016; Liu et al., 2019). Underrepresented minority populations also suffer from higher attrition rates in STEM subjects than their peers (Johnson & Walton, 2015; Liu et al., 2019). Universities must focus on recruiting these populations to STEM majors and increasing their efforts to retain these students throughout their college careers (Snyder et al., 2016). The lack of diversity in STEM career fields directly impacts scientific achievement in today’s technology-rich society (Kang et al., 2019; Liu et al., 2019).

Several factors affect the retention of students in STEM courses. Mentoring, learning styles, passing grades, social networking, and maintaining a science identity contribute to the success, or failure, of minority students in STEM. Many students of color in low-income communities view STEM subjects as confusing and frustrating (King & Pringle, 2019). Using laptops can assist with the retention of underrepresented students in STEM majors. Many schools are abandoning traditional pedagogical methods in favor of active learning strategies such as "flipped classrooms." In one study, students in a freshman-level biology course performed better using Peer-Led Team Learning (PLTL; Snyder et al., 2016). Minority students in the study, specifically, experienced a drastic reduction in failure rates at the end of the course. PLTL includes small group interactions that use technology to assist with organizing, communicating, and understanding. Laptops can be used in any classroom as part of PLT, as can handheld devices such as clickers (Snyder et al., 2016).

Employment in STEM fields is a financially sound career choice. Research reports that salaries in science, technology, engineering, or mathematics are double those of other occupations and are projected to grow twice as fast (Liu et al., 2019). However, the demand for employees to enter and remain in STEM careers is not being met due to what some experts call the "leaky pipeline" (Breiner, 2016). A large gap exists in the population of students who declare a STEM major compared to the actual number of students who graduate with a STEM degree (Breiner, 2016; Campos-Castillo, 2015; Johnson & Walton, 2015; Liu et al., 2019). Between 2003 and 2009, one university reported that half of the 28% of the student population who began a bachelor's degree in a STEM program did not graduate with the same degree, either due to changing majors or leaving the university entirely (Johnson & Walton, 2015). Just 20% of STEM-interested underrepresented minority students complete their STEM degrees (Freeman et al., 2014). The globalized economy has created a demand for highly skilled workers, and by 2028, there may be a shortage of 2.4 million STEM jobs that are unlikely to be filled (Ball et al., 2020). Despite various programs created to help stop the departure of women from the STEM career tract, women and women of color continue to be underrepresented (Ball et al., 2020).

The Digital Divide

From the introduction of the steam engine and electricity to advanced capabilities like AI, the pace of technology continues to increase while the cost to obtain it continues to decrease, making technology accessible to everyone (Kocdar et al., 2021; Lewis, 2020). The use of one-to-one technology may have positive effects on students who are minorities, eligible to receive special education services, and classified as living in low socio-economic conditions (Grundmeyer & Peters, 2016; Harper & Milman, 2016; Hull & Duch, 2019; Johnson & Walton, 2015). Providing technology to all students eliminates the economic divide that hinders many marginalized populations from device access due to acquisition and maintenance costs (Holen et al., 2017; Larkin, 2014).

African American and Latinx women specifically are underrepresented in physical science careers (Kang et al., 2019). This may be due to what is referred to as an *access gap* or a *second-level divide* in the level of access to computers and computer software for minorities. Students need access to computers and the Internet to be able to participate in a fully digital life (Ball et al., 2020). Many students of color in economically-challenged communities struggle to attain equitable access to technology (Ball et al., 2020; King & Pringle, 2019). There are access gaps in computer materials and gaps in skills, which hinder students' feelings of computer self-efficacy (Ball et al., 2020). The gaps in skills and the gains in digital literacy are considered second-level digital divides. The third level divides are the outcome gains that develop from Internet usage. There is a renewed focus now on how second and third-level digital divides are affected by first-level divides (Reisdorf et al., 2020). The more opportunities that predominately minority students have to use computers, the more they are able to develop computational skills (Ball et al., 2020).

Summary

The benefits of using technology in classrooms across the United States continues to be a hotly debated subject (Grundmeyer & Peter, 2016). To date, there are very few longitudinal and quantitative studies that attempt to connect academic achievement with the use of technology in the classroom (Doron et al., 2019). Schools that have previously refrained from purchasing technology before the COVID-19 pandemic are scrambling to implement programs that allow students an opportunity to learn using technology from home (Burns et al., 2020; Iivari et al., 2020; Middleton, 2020). Millions of dollars have been spent on purchasing equipment, training educators and staff, and building a supportive infrastructure in schools to allow every student, educator, and administrator to use technology (Barak, 2016; Engelhardt et al., 2021; Holen et al., 2017). District- and state-wide stakeholders expect students and teachers to use technology purposefully and thoughtfully to enhance student learning outcomes (Kwon et al., 2019). What remains to be determined is whether these initiatives benefit learning or hinder student attention, knowledge construction, and district finances. Continued studies and research can add to the body of literature, providing necessary support to school districts that are trying to see through a glass darkly when it comes to utilizing one-to-one technology in the classroom.

CHAPTER THREE: METHODS

Overview

The benefits of one-to-one technology in K-12 education continue to be hotly debated in the United States and globally (Liu et al., 2017). The purpose of this causal-comparative study was to assess the impact of using one-to-one technology in Grade 7 on student achievement scores as measured by the South Carolina Palmetto Assessment of State Standards (SCPASS) exam in the subjects of science and social studies. Chapter Three addresses the study design, research questions, participants, setting, instrumentation, procedures and concludes with data analysis.

Design

The researcher used a causal-comparative design to frame this study. Causal-comparative methods provide comparisons of participants based on some existing conditions. The independent variables are pre-determined with this type of study (Martella et al., 2013). A limitation of causal studies is that cause-and-effect relationships may not be attributed solely to differences in data but may be due to group characteristics that existed before the study (Gall et al., 2007; Gopalan et al., 2020).

This study was not considered a true experiment because it lacks randomly assigned participants to groups (Gall et al., 2007; Kim & Steiner, 2016). Using this method may threaten the validity of internal data; however, using true experimental design can be costly and unwieldy for policy-driven interventions (Gopalan et al., 2020; Kim & Steiner, 2016). The study used a static-group comparison design because the outcome was measured on a non-randomly assigned group of participants (Creswell & Creswell, 2018; Gall et al., 2007). Testing for differences in the design was the most appropriate choice for this research because it entailed a quantitative analysis involving four different groups (Gall et al., 2007; Warner, 2013).

For this study, the dependent variable was the content knowledge in science and social studies, as reported on the South Carolina Palmetto Assessment State Standards (SCPASS) exam. Student achievement is commonly measured by state assessments in grades K–12 (Martino, 2021). The independent variable for this study was one-to-one technology for females and males. The covariate identified in this study consisted of the Grade 6 SCPASS scores in science and social studies.

Research Questions

The researcher developed the following research questions to guide the study:

RQ1: Is there a difference in science achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ2: Is there a difference in science achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ3: Is there a difference in social studies achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ4: Is there a difference in social studies achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

Hypotheses

The null hypotheses for this study were:

$H_0$1: There is no difference in science achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

$H_0$2: There is no difference in science achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

$H_0$3: There is no difference in social studies achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

$H_0$4: There is no difference in social studies achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

Participants and Setting

This study used public archival achievement scores from the South Carolina Palmetto Assessment of State Standards (SCPASS) that are reported by the South Carolina Department of Education. For this study, the number of cases was more than 800 students per subgroup. The four subgroups contained 3,747 participants in the subject of social studies and 3,745 participants in the subject of science. These case numbers exceeded the minimum population for a medium effect size (Gall et al., 2007). Using an alpha level of 0.05, a statistical power of 0.70, and a medium effect size of 0.25, the current study needed a minimum of 101 cases per group because the statistical power increases with the number of participants in a sample (Faul et al., 2007; Gall et al., 2007). The cases were divided into their respective school districts before this study, based on students' geographic proximity, so the study was also classified as *ex post facto* (Gall et al., 2007). See Table 1 for the population divided by school and one-to-one technology use.

Table 1

Number of Female and Male Students for Each Subject Separated by School District

School District	Subject	
	Social Studies	Science
District A Females	818	818
District A Males	882	882
District B Females	978	977
District B Males	1,069	1,068
Total	3,747	3,745

The research focused explicitly on laptops to determine if a school should be categorized as having provided one-to-one technology. The researcher did not include technology such as clickers or Classroom Response Systems (CRS) in the study because they are not as widely used as laptops. Additionally, the requirement for a school to be placed in the "technology providing group only needed to supply information that one-to-one technology was purchased for every student in Grades 6 and 7 for use during the school day.

The average demographics of the school district that did not use one-to-one technology were 75.3% Caucasian, 11.3% African-American, 2.1% Asian, 0.2% American Indian, 0.1% Native Hawaiian, and 3.8% two or more races. The school district that self-identified as using one-to-one technology and that purchased and provided a laptop for every student in Grade 7 included 71.3% African-American, 18.7%, Caucasian, 1.1% Asian, 0.0% American Indian, 0.1% Native Hawaiian, and 4.0% two or more races. A total of 4.5% of the technology schools were classified as Limited English Proficiency (LEP) and the rate was 5.1% for schools without technology. Up to 12.1% of students received special education services in schools without technology, compared to 15.9% of students in schools that used technology. For students in poverty (SIP), School District A reported that 72.3% of the population identified as SIP, compared to 41.5% in School District B. When comparing males to females, 818 female students in the schools used technology and 882 males. However, 978 females and 1,068 boys did not use one-to-one technology. Table 2 displays participant demographics for Grade 7 students who used technology, and Table 3 shows the Grade 7 students who did not use technology.

Table 2

Grade 7 Participant Demographics Technology – School District A

Demographics		Participants (*N*)	Participants (%)
Gender	Female	818	48.1
	Male	882	51.9
	Total	1,700	100
Race/ethnicity	African America	1,212	71.8
	American Indian	0	0
	Asian	18	1.1
	Caucasian	318	18.7
	Hawaiian	2	0.1
	Hispanic	81	4.8
	Two or more races	68	4.0

Table 3

Grade 7 Participant Demographics Non-Technology – School District B

Demographics		Participants (*N*)	Participants (%)
Gender	Female	978	47.8
	Male	1,069	52.2
	Total	2,047	100
Race/ethnicity	African American	232	11.3
	American Indian	4	0.2
	Asian	43	2.1
	Caucasian	1,542	75.3
	Hawaiian	1	0.1
	Hispanic	147	7.2
	Two or more races	78	3.8

For Grade 6 demographics, School District B included 75.4% Caucasian students, 11.2% African-American students, 11.2% Asian students, 0.2% American Indian students, 7.1% Hispanic students, 0.1% Native Hawaiian students, and 3.9% students who identified as two or more races. School District A consisted of 71.3% African-American students, 18.5% Caucasian students, 1.4% Asian students, 0.0% American Indian students, 4.4% Hispanic students, 0.1% Native Hawaiian students, and 3.8% who identified as two or more races. A total of 4.2% of students were classified as Limited English Proficiency (LEP) for School District A and 5.3% for

School District B. Up to 12.9% of students received special education services in School District B, compared to 15.7% of students in School District A. There were 1,748 Grade 6 students in School District A and 2,006 Grade 6 students in School District B. See Tables 4 and 5 for demographic information for each district.

Table 4

Grade 6 Participant Demographics Technology – School District A

Demographics		Participants (*N*)	Participants (%)
Gender	Female	910	52.2
	Male	835	47.8
	Total	1,748	100
Race/ethnicity	African America	1,259	71.7
	American Indian	0	0
	Asian	24	1.4
	Caucasian	323	18.5
	Hawaiian	2	0.1
	Hispanic	77	4.4
	Two or more races	66	3.8

Table 5

Grade 6 Participant Demographics Non-Technology – School District B

Demographics		Participants (*N*)	Participants (%)
Gender	Female	946	47.2
	Male	1,060	52.8
	Total	2,006	100
Race/ethnicity	African America	224	11.2
	American Indian	4	0.2
	Asian	42	2.1
	Caucasian	1,513	75.4
	Hawaiian	1	0.1
	Hispanic	143	7.1
	Two or more races	78	3.9

Instrumentation

The researcher chose the SCPASS exam as the instrument for this study. The purpose of this exam is to follow the mandate of the Education Accountability Act (EAA), Title 59, Chapter

18 that requires accountability in public education through the use of performance-based assessments. It was developed in the spring of 2009 and is administered to all Grade 3 through Grade 8 students in public K–12 schools in South Carolina during the last 20 days of school (South Carolina Department of Education, 2020). The test is not timed and is completed using a computer. If students cannot complete the test using this format based on accommodations specified in a 504 or Individualized Education Plan (IEP), they are allowed to take the test using a paper format. The test includes grade-appropriate questions in science and social studies, and the results are reported to parents, educators, and the public for each school district. The tests are given on separate days and contain multiple-choice and technology-enhanced (TE) items (SCPASS Test Administration Manual, 2020).

In 2018, the test was modified to test only Grade 4, 6, and 8 students in science and Grade 5 and 7 students in social studies. The COVID-19 pandemic halted formalized testing in South Carolina for the 2019–2020 school year, and the test was not administered (Schiferl, 2020). The state legislature passed the Standardized Testing Overburdens Pupils (STOP) Act, which retracted state funding for any educational assessments required by state law for the 2019–2020 school year (STOP Act, 2019). For this reason, the researcher chose to analyze the SCPASS scores during the 2016–2017 school year so that the data remained consistent throughout the Grade 7 reporting assessment scores. The exam results are divided into four rankings for the subject of science: *Does Not Meet Expectations*, *Approaches Expectations*, *Meets Expectations*, and *Exceeds Expectations*. The scores range from 1670 to 1830. In the subject of social studies, there are three sub-rankings: *Not Met*, *Met*, and *Exemplary*. Social studies scores range from 300 to 900 (South Carolina Department of Education, 2020). See Appendix C for the complete list of cutoff scores for each assessment subject.

In addition, the South Carolina Department of Education publishes demographics associated with the students who complete the SCPASS each year. The demographics report includes K–12 enrollment, the number of students who qualify for free or reduced lunches, the number of English Language Learner (ELL) students, the number of enrolled students who receive special education services, the number of students who identify as African-American, American Indian, Asian, Caucasian, Hawaiian, Hispanic, two or more races, as well as achievement results for female and male students. The use of archival research can resolve the limitations of traditional laboratory experiments and has been used in the fields of economics, sociology, and developmental psychology. A recently published study used data from the SCPASS exam to determine a negative relationship between increased county opioid prescriptions and test scores in students who attend South Carolina public schools in Grades 3 through 8 (Cotti et al., 2020).

Procedures

The researcher acquired permission from each school district that chose to participate. They also submitted an application to the Institutional Review Board (IRB) of Liberty University, which the university approved (see Appendix A). The researcher also contacted district personnel in charge of information technology (IT) via email to inquire whether the district used one-to-one technology in their middle schools for Grades 6 through 7 during the 2016–2017 school years. The email briefly described the study (see Appendix B). The districts that reported "yes" to the question of providing one-to-one technology to students in Grade 7 during the 2016–2017 school years were placed into the computer technology group, which was identified as School District A. If the districts responded "no" on the same question, they were placed in the non-computer technology group, labeled School District B. The researcher gathered the SCPASS data from the districts that responded to the email. The study did not require human participation, so parental and individual school permission was not required. The researcher did not publish district names and identifying information and protected student privacy because there is no identifying information linking individual characteristics to student test scores.

The researcher entered all data into a database for analysis using the Statistical Package for Social Sciences (SPSS). The data were stored on two devices the researcher owned: one desktop and one laptop. Both devices were password protected, and only the researcher knew the password. The computers were configured to "lock out" after 10 minutes of inactivity. The raw data will be kept for a minimum of 3 years. After this time, the researcher will permanently delete any electronic documents and files on the memory drives of desktop and laptop computers they own.

Data Analysis

The researcher chose the Analysis of Covariance (ANCOVA) linear model for this study because it can control the pre-test effect (Gall et al., 2007). They conducted four ANCOVAs because there were four hypotheses (Warner, 2013). ANCOVA analysis is a way to control for initial individual differences, such as gender and the subjects of science and social studies, which cannot be randomized (Gall et al., 20077). ANCOVA allows the researcher to compare mean student performance on the Grade 7 test scores for each participant group, with the Grade 6 scores used as a covariate. In a similar study, Hyer and Waller (2014) reported that ANCOVA was an effective statistical analysis method to test differences on a post-test while controlling for pre-test scores in their two-group repeated measures experimental design. ANCOVA was warranted because this study sought to assess the possible difference between groups of an independent variable on the dependent variable, while controlling for initial differences in the non-equivalent groups (Gall et al., 2007; Warner, 2013). Specifically, through the analysis of the current study's data, the researcher sought to determine if any statistically significant differences existed between test scores on the SCPASS exams of students who used one-to-one technology and students who did not use one-to-one technology. The researcher inspected the data visually to ensure there were no inaccuracies or missing data points. They also conducted a test for differences in a box-and-whiskers plot for each group to look for extreme outliers (Warner, 2013).

The researcher conducted a Kolmogorov-Smirnov test for normality using SPSS software. One assumption made by an ANCOVA test is that the relationships between variables are linear and that all individual groups have the same slope. The assumption can be checked by performing an *F* test (Gall et al., 2007; Warner, 2013). In addition, the researcher used Levene's test of equality of error variance to compare two or more groups for a quantitative variable (Gall et al., 2007). They also completed a test for the assumption of homogeneity of slopes using SPSS software to look for interactions. Moreover, they reported descriptive statistics based on the mean and standard deviation of the dependent variable for each independent variable.

The alpha was set to 0.05 and the power to 0.70. Since there were four significance tests, a Bonferroni correction was needed to guard against a type I error (Warner, 2013). The alpha level was calculated to be 0.05/4=.0125, rounded to 0.013 (Gall et al., 2007). The researcher conducted an Eta-squared analysis to determine the effect size. They then compiled the results to determine any statistical differences between students who used one-to-one technology in the classroom and students who did not use one-to-one technology on state-mandated tests.

CHAPTER FOUR: FINDINGS

Overview

This quantitative, causal-comparative study assessed hypothesized differences in science and social test scores between Grade 7 male and female students who used one-to-one technology and those who did not have access to one-to-one technology. This chapter reviews the research questions and hypotheses, summarizes the descriptive statistics for each, and then presents narrative and visual results of the one-way analysis of covariance (ANCOVA) employed to analyze this study's data. A summary of the results concludes the chapter.

Research Questions

The researcher developed the following research questions to guide the study:

RQ1: Is there a difference in science achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ2: Is there a difference in science achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ3: Is there a difference in social studies achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

RQ4: Is there a difference in social studies achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores?

Null Hypotheses

The null hypotheses for this study were:

$H_0$1: There is no difference in science achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

$H_0$2: There is no difference in science achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

$H_0$3: There is no difference in social studies achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

$H_0$4: There is no difference in social studies achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 achievement scores.

Descriptive Statistics

Descriptive statistics for this study used data published on the South Carolina Department of Education website in science and social studies for Grade 7 students. The possible scores for the science test ranged from 1670 to 1830, while the possible scores for the social studies test ranged from 300 to 900. School District A used one-to-one technology during the 2016–2017 school years, while School District B did not provide one-to-one technology during the same school year. The total number of students tested for School District A was 1,700, and the total number of students tested for School District B was 2,047. The science and social studies scores were higher in School District B for females (M=1,751; SD=21.5) and males (M=1,752; SD=19.8) compared to the scores for females in School District A (M=1,749; SD=22.4) and males (M=1,746; SD=23.0).

The researcher gathered the data in a Microsoft Excel document and entered them into the SPSS software (Version 28) for data analysis. The descriptive statistics used SPSS to analyze the data for both subjects and both types of schools. The researcher received Excel spreadsheets with only the districts' names and test scores for the seventh grade. In the variable values section of the software, the school districts that used one-to-one technology were labeled School District A, and the schools that did not provide one-to-one technology were labeled School District B. Tables 6 and 7 show the descriptive statistics for the minimum, maximum, mean, and standard deviations of each group of Grade 7 test scores, while Tables 8 and 9 show the descriptive statistics of each group of Grade 6 test scores.

Table 6

Descriptive Statistics for Grade 7 SCPASS Science Scores – School Districts A and B

SCPASS Science Score District A						SCPASS Science Score District B				
Gender	*N*	Min.	Max.	*M*	*SD*	*N*	Min.	Max.	*M*	*SD*
Female	818	1,670	1,830	1,749	22.4	978	1,670	1,830	1,752	19.8
Male	882	1,670	1,830	1,746	23.0	1,069	1,670	1,830	1,751	21.5

Table 7

Descriptive Statistics for Grade 7 SCPASS Social Studies Scores – School Districts A and B

SCPASS Social Studies Score District A						SCPASS Social Studies Score District B				
Gender	*N*	Min.	Max.	*M*	*SD*	*N*	Min.	Max.	*M*	*SD*
Female	818	300	900	616.4	47.4	977	300	900	629.8	52.0
Male	882	300	900	616.2	53.4	1,068	300	900	635.5	57.7

Table 8

Descriptive Statistics for Grade 6 SCPASS Science Scores – School Districts A and B

SCPASS Science Score District A						SCPASS Science Score District B				
Gender	*N*	Min.	Max.	*M*	*SD*	*N*	Min.	Max.	*M*	*SD*
Female	835	1570	1730	608.5	53.3	946	1570	1730	632.4	51.1
Male	910	1570	1730	601.0	60.5	1060	1570	1730	629.1	58.9

Table 9

Descriptive Statistics for Grade 6 SCPASS Social Studies Scores – School Districts A and B

SCPASS Social Studies Score District A						SCPASS Social Studies Score District B				
Gender	*N*	Min.	Max.	*M*	*SD*	*N*	Min.	Max.	*M*	*SD*
Female	835	300	900	609.0	53.1	946	300	900	650.3	52.3
Male	910	300	900	601.2	60.7	1060	300	900	629.1	58.9

Results

The data analysis included a one-way analysis of covariance (ANCOVA) in which the Grade 6 test scores were the covariate and the Grade 7 test scores were the dependent variable. Moreover, computer use was the independent variable of two types: the use of one-to-one technology and the absence of one-to-one technology. The researcher performed five different assumptions tests for the ANCOVA model used for this study: normality, linearity, bivariate normal distribution, homogeneity of the slope, and equal variances. This results section also includes the decision whether to reject or fail to reject the null hypotheses.

Null Hypothesis One

Null hypothesis one indicated no difference in science achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling Grade 6 female science achievement scores.

Data Screening

The researcher conducted box-and-whisker plots for data screening of the dependent, independent, and covariate variables to remove incomplete or inaccurate data. No missing values were detected for either variable. They also conducted a box-and-whisker plot for each group and reviewed them to look for extreme outliers. They screened the data visually to ensure no missing data points and that all data entry was correct. Upon examining the first boxplot related to the Grade 7 science achievement scores for females, there were 13 outliers detected. For the covariate Grade 6 achievement scores of science of females, there were 11 outliers detected. The researcher checked the data for errors, and all entries were correct. Furthermore, upon inspection of the histograms and the Kolmogorov-Smirnov test, the researcher observed a normal distribution of data, so they accepted all of the data points (Warner, 2013). Subsequently, converting the outliers to standard scores revealed that all fell within a +3 and -3 standard deviations of the sample mean (Warner, 2013, p. 153). Figures 1 and 2 show the box-and-whisker plots for Grade 7 and 6 female science scores.

Figure 1

Box-and-Whiskers Plot for Grade 7 Female Science Scores – School Districts A and B

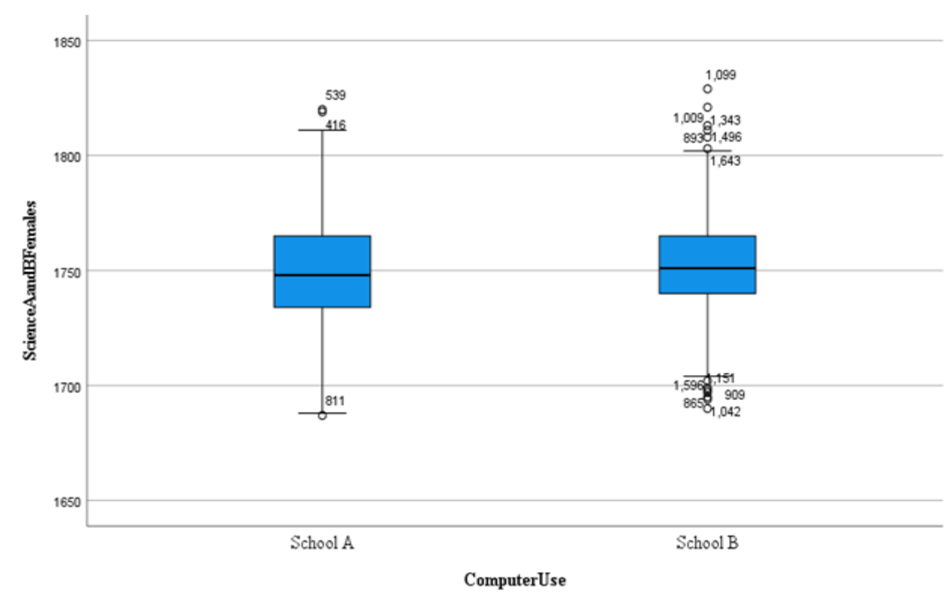
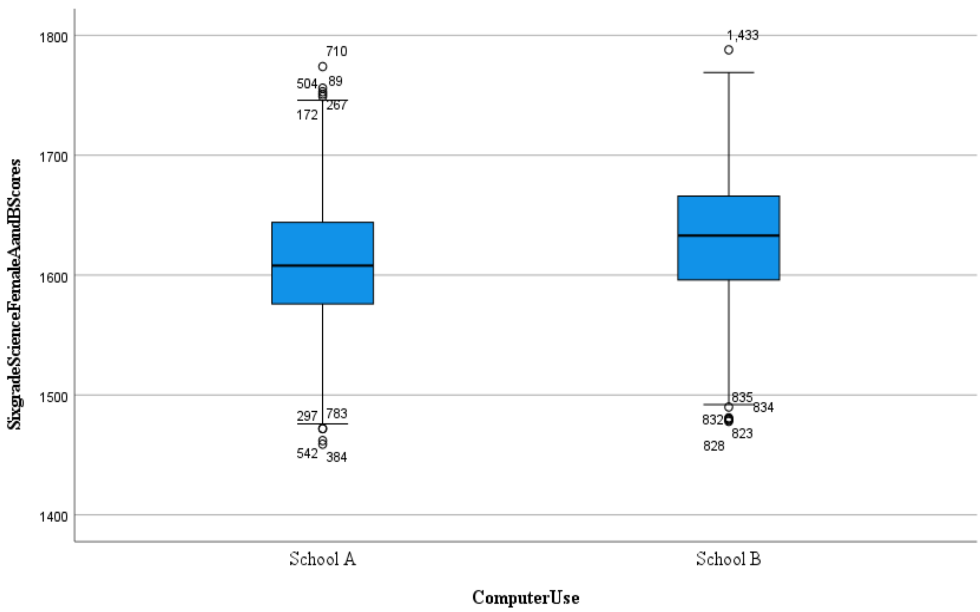


Figure 2

Box-and-Whiskers Plot for Grade 6 Female Science Scores – School Districts A and B



Assumptions Testing

Because the researcher used an ANCOVA to test the null hypothesis, they assessed the following assumptions: normality, linearity, bivariate normal distribution, homogeneity of slopes, and the homogeneity of variance. The Kolmogorov-Smirnov statistical analysis also tested for the normality of the distribution. The statistical analysis indicated that the data did not violate the assumption of normality for either School District A or School District B. See Table 10 for the tests of normality.

Table 10

Tests of Normality

		Kolmogorov-Smirnov		
Groups		Statistic	*df*	Sig.
Grade 7	1 – School A	0.029	818	0.115
Females	2 – School B	0.033	977	0.114
Grade 6	1 – School A	0.018	910	0.200
Females	2 – School B	0.026	946	0.119

The assumption of normality also presumes a bell curve shape on a histogram (Rovai et al., 2014). The researcher observed normal distribution shapes for each histogram for Grade 7 and Grade 7 female student scores in science. The data, therefore, appeared normally distributed. See Figures 3 and 4 for the histograms of Grade 7 and Grade 6 female science scores for School Districts A and B.

Figure 3

Histograms of Grade 7 Female Science Scores – School Districts A and B

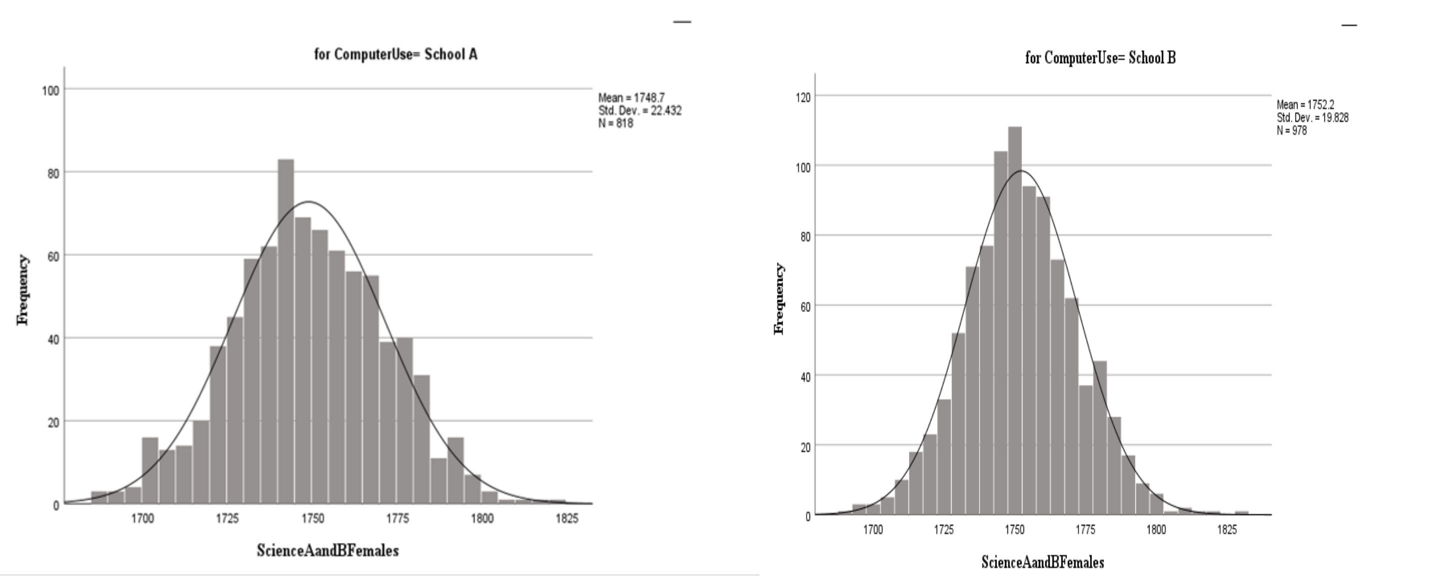
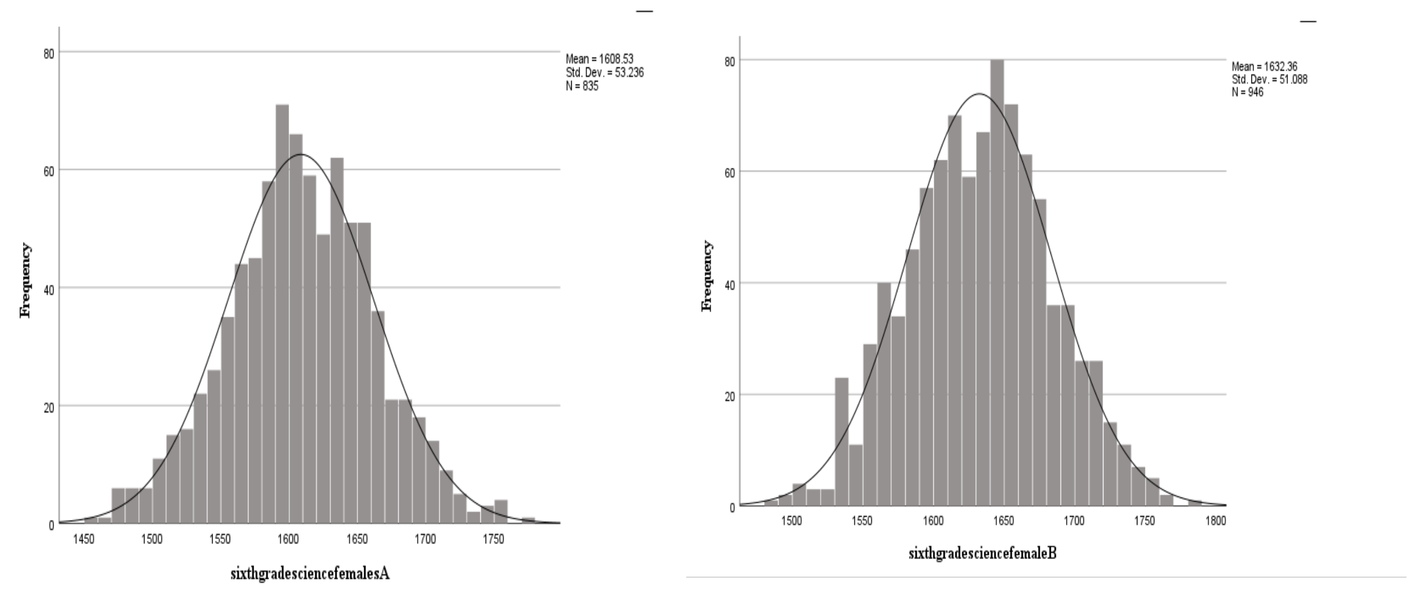


Figure 4

Histograms of Grade 6 Female Science Scores – School Districts A and B



The researcher tested the assumption of linearity and bivariate normal distribution using scatter plots for each group. They then investigated the slopes of regression relationship using a scatter plot. Upon inspection, there was a linear relationship between Grade 6 and 7 female science scores (Warner, 2013). See Figures 5 and 6 for the scatterplots of Grade 6 and 7 female test scores by computer use.

Figure 5

Scatterplot of Grade 6 and 7 Female Science Test Scores – School District A

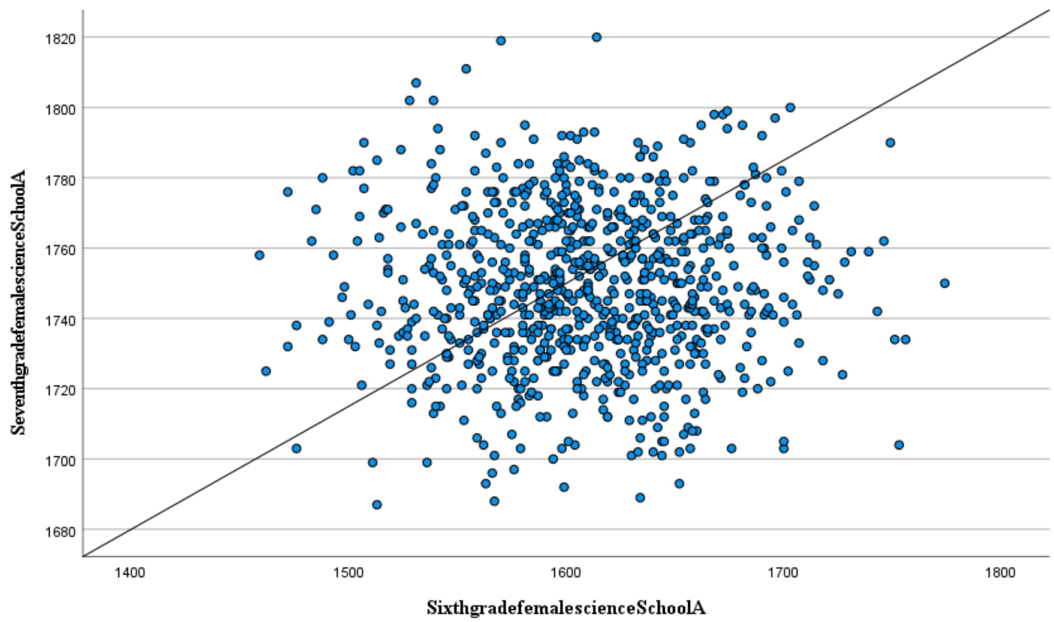
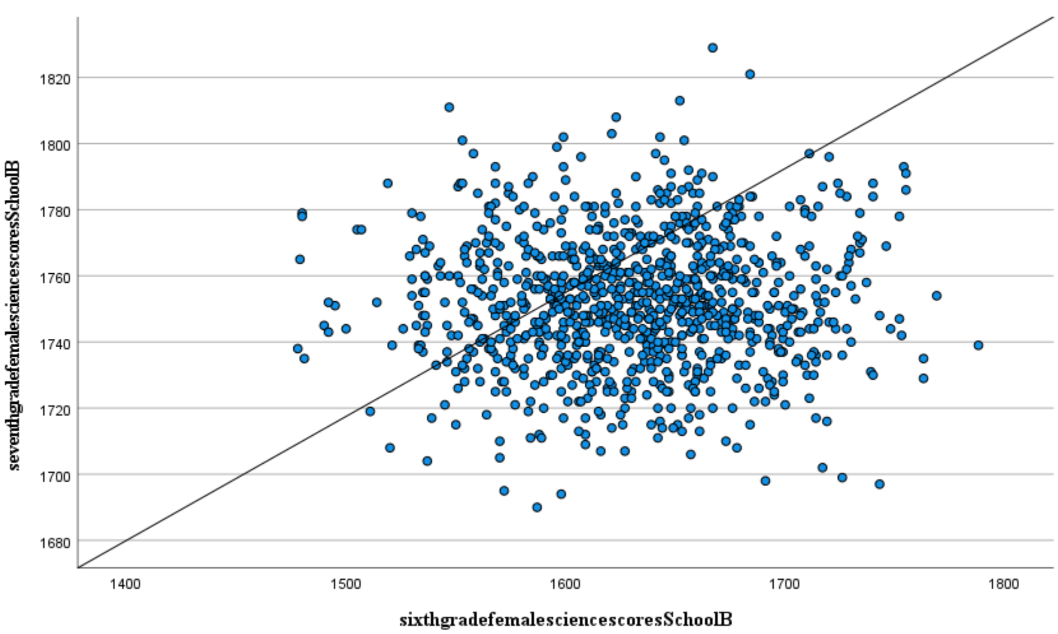


Figure 6

Scatterplot of Grade 6 and 7 Female Science Test Scores – School District B



The researcher tested the assumption of homogeneity of slopes and found no interaction where p=0.068. Therefore, the assumption of homogeneity of slope was met. As seen in Table 11, regression slopes were homogeneous; the interaction term was not statistically significant, with $F(1, 1792)$=3.339 and p=0.068. The assumption of homogeneity of regression slopes was tenable. See Table 11 for the results of the homogeneity of regression slopes for Grade 7 female science scores in School Districts A and B, with Grade 6 female science scores as the covariate.

Table 11

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	n^2
Corrected Model	7,046.41[a]	3	2,348.81	5.30	<0.001	0.009
Intercept	5,484,403.99	1	5,484,403.99	125,383.50	<0.001	0.874
Computer Use	233.15	1	233.15	0.53	0.468	0.000
Computer Use* Grade 6 Science Female A and B Scores	1,478.72	1	1,478.72	3.34	0.068	0.002
Error	79,364.70	1792	442.88			
Total	5,504,855,845	1795				
Corrected Total	800,687.11	1795				

Note. [a] R Squared=0.009 (Adjusted R Squared=0.007)

The next assumption involved the homogeneity of variance. This assumption tested the variance within each population. To test this assumption, the researcher conducted Levene’s test, $F(1,1782)$=15.79. As the results of the test indicate (p=0.08), there was homogeneity of variance present. The assumption of homogeneity of variance was met.

Results for Null Hypothesis

The researcher used an ANCOVA to test the differences between Grade 7 female science test scores for students who used one-to-one technology and Grade 7 female students who did not, while controlling for Grade 6 female science test scores. The null hypothesis was rejected at the 95% confidence level: $F(1,1793)=9.56$; $p=0.002$; partial $\eta^2=0.005$. The effect size was considered to be weak with a partial $\eta^2=0.005$ when interpreted in light of a 0.25 level of effect size and a statistical power of 0.5 (Gall et al., 2007; Warner, 2013). The small effect size indicated there may be limited practical applications to the research. Because the null was rejected, the researcher conducted a Bonferroni post hoc test (Warner, 2013). School District B female science test scores were statistically significantly greater ($M_{diff}=3.00$; $SE=1.02$; 95% CI [1.00, 5.01]; $p=0.003$) compared to School District A female science test scores ($M_{diff}=-3.00$; $SE=1.02$; 95% CI [-5.01, -1.00]; $p=0.003$). See Table 12 for the multiple comparisons of groups.

Table 12

Multiple Comparisons of Groups

					95% Confidence Interval for Difference[b]	
(I) Computer Use	(J) Computer Use	Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
School A	School B	-3.009*	1.021	0.003	-5.012	-1.007
School B	School A	3.009*	1.021	0.003	1.007	5.012

Based on estimated marginal means. * The mean difference is significant at the 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni

Null Hypothesis Two

Null hypothesis two indicated no difference in science achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 male science achievement scores.

Data Screening

The researcher used a box-and-whiskers plot to test the normality of social studies scores for Grade 6 and 7 male students on the SCPASS exam. The researcher reviewed the data for inaccuracies and found none. Figure 7 for Grade 7 science male scores contained 9 outliers, and the covariate, which consisted of Grade 6 science male scores, contained 10 outliers. The researcher entered the data points into the software correctly. The researcher also kept all of the data points because omitting them would alter the outcome, and they observed a normal distribution of data on the histograms and on the Kolmogorov-Smirnov test (Warner, 2013). Furthermore, converting the outliers to standard scores revealed that all fell within +3 and -3 standard deviations of the sample mean (Warner, 2013, p. 153). See Figures 7 and 8 for the box-and-whisker plots for Grade 7 and Grade 6 male science scores.

Figure 7

Box-and-Whiskers Plot for Grade 7 Male Science Scores – School Districts A and B

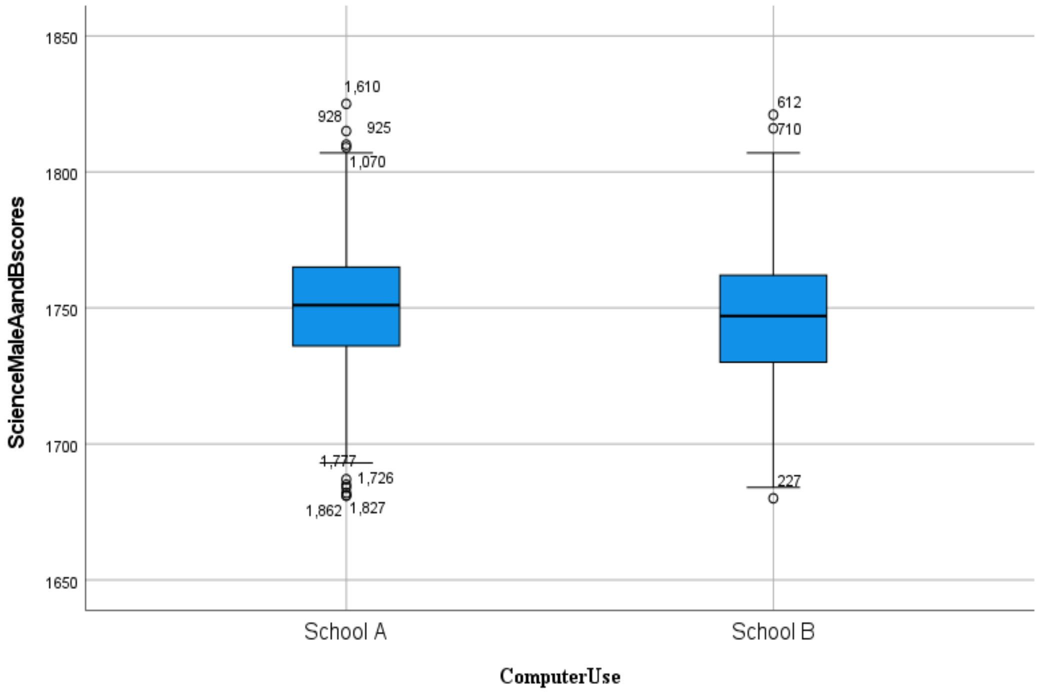
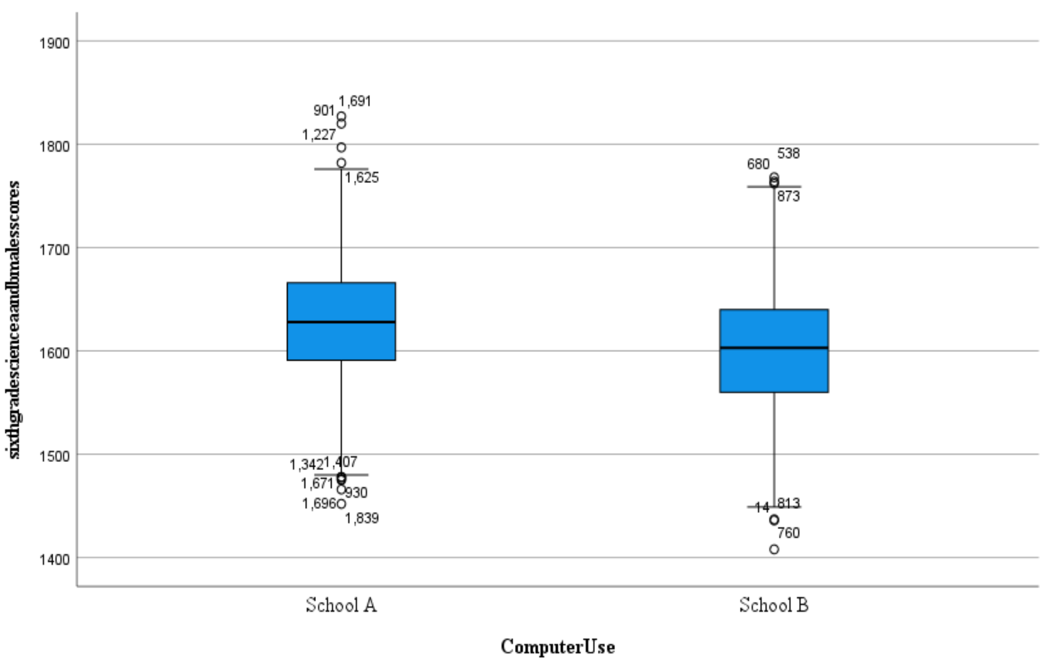


Figure 8

Box-and-Whiskers Plot for Grade 6 Male Science Scores – School Districts A and B



Assumptions Testing

Because the researcher used an ANCOVA to test the null hypothesis, they assessed the following assumptions: normality, linearity, bivariate normal distribution, homogeneity of slopes, and the homogeneity of variance. The statistical analysis can also be used to test for the normality of the distribution. The Kolmogorov-Smirnov statistical analysis indicated that the data did not violate the assumption of normality for either School District A or B. See Table 13 for the tests of normality.

Table 13

Tests of Normality

		Kolmogorov-Smirnov		
Groups		Statistic	*df*	Sig.
Grade 7	1 – School A	0.020	882	0.200
Males	2 – School B	0.017	1,069	0.200
Grade 6	1 – School A	0.021	835	0.200
Males	2 – School B	0.023	1,060	0.200

For the assumption of normality, a bell-shaped curve would describe the overall shape of a histogram (Rovai et al., 2014). The researcher observed normal distribution shapes for Grade 7 and Grade 6 male science scores in School Districts A and B on each histogram. Therefore, the scores reflected reasonable normal distribution. Figures 9 and 10 show the histograms of Grade 7 and Grade 6 male science achievement scores in School Districts A and B.

Figure 9

Histograms of Grade 7 Male Science Scores – School Districts A and B

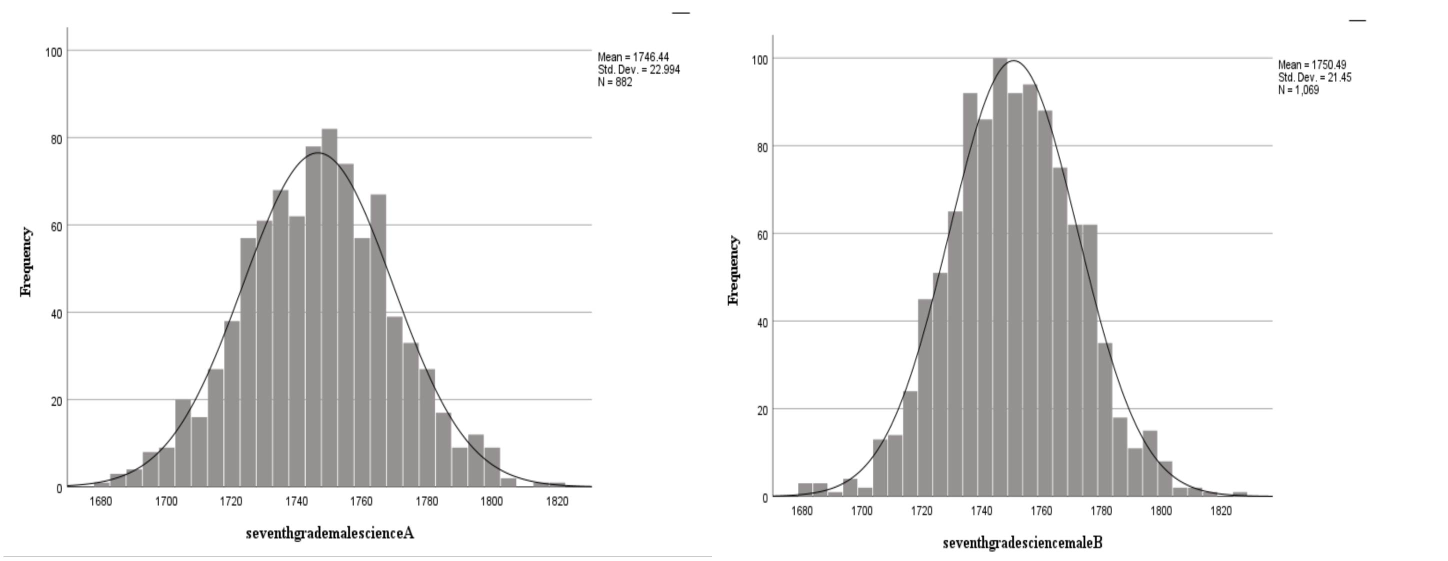
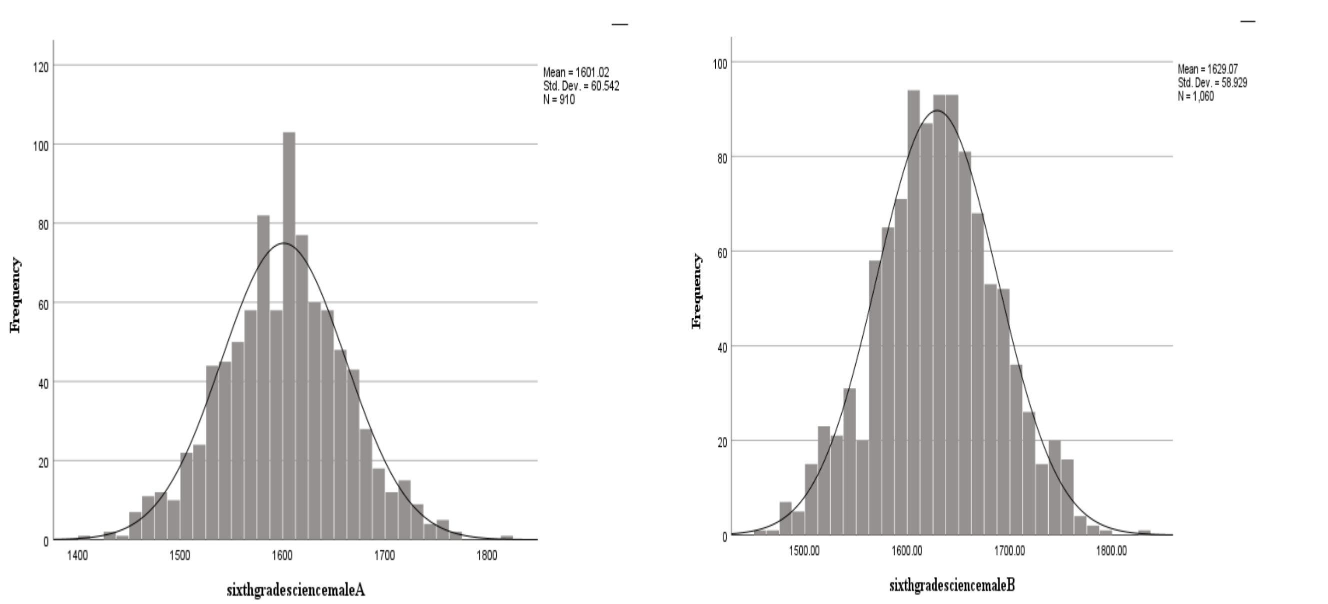


Figure 10

Histograms of Grade 6 Male Science Scores – School Districts A and B



The researcher tested the assumption of linearity and bivariate normal distribution using scatter plots for each group. They also investigated the slopes of regression relationship using a scatter plot. Upon inspection, there was a linear relationship between Grade 6 and Grade 7 male science scores (Warner, 2013). See Figures 11 and 12 for the scatterplots of Grade 6 and 7 male test scores by computer use.

Figure 11

Scatterplot of Grade 6 and 7 Male Science Test Scores – School District A

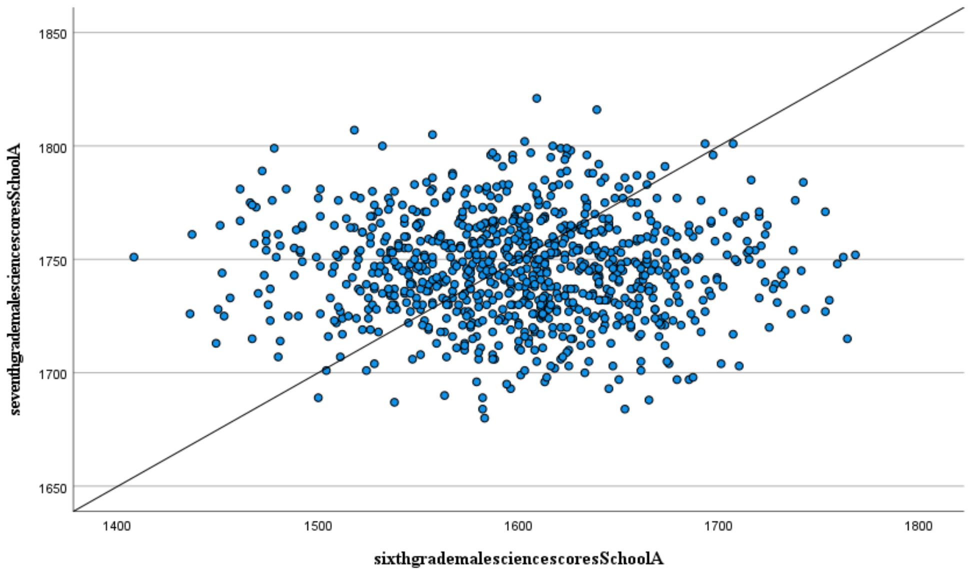
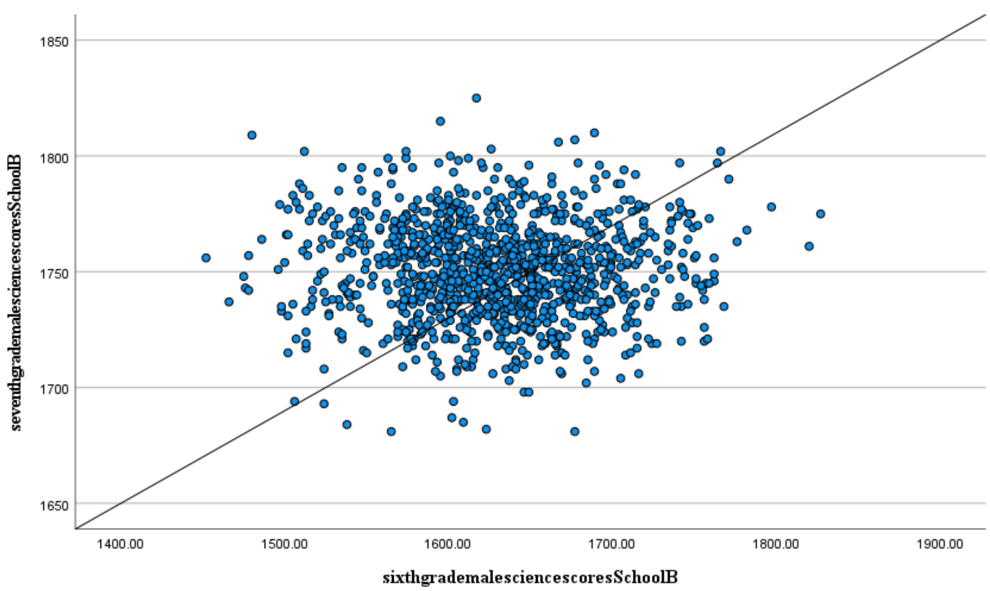


Figure 12

Scatterplot of Grade 6 and 7 Male Science Test Scores – School District B



The researcher tested the assumption of homogeneity of slopes and found no interaction, where p=0.686. Therefore, the assumption of homogeneity of slope was met. As seen in Table 14, the regression slopes were homogeneous as the interaction term was not statistically significant: $F(1,1947)=0.16$; p=0.686. The researcher deemed the assumption of homogeneity of regression slopes to be tenable. See Table 14 for the results of the homogeneity of regression slopes for Grade 7 male science scores in School Districts A and B, with Grade 6 male science scores as the covariate.

Table 14

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	n^2
Corrected Model	8622.54[a]	3	2874.18	5.85	<0.001	0.009
Intercept	8172987.71	1	8172987.71	16636.43	<0.001	0.895
Computer Use	29.72	1	29.72	0.06	0.806	0.000
Grade 6 Science A and B Male Scores	101.62	1	101.62	0.21	0.649	0.000
Computer Use* Grade 6 Science Male A and B Scores	80.07	1	80.07	0.16	0.686	0.000
Error	956503.86	1947	491.27			
Total	5966771118	1951				
Corrected Total	965126.41	1950				

Note. [a.] R Squared=0.009 (Adjusted R Squared=0.007)

Next, the researcher tested the homogeneity of variance assumption. This assumption tests the variance within each population. To test this assumption, the researcher used Levene's test: $F(1,1949)=3.45$. As the results of the test indicated (p=0.064), there was homogeneity of variance present. The assumption of homogeneity of variance was met.

Results for Null Hypothesis

The researcher used an ANCOVA to test the differences between Grade 7 male science test scores for students who used one-to-one technology and Grade 7 male students who did not, while controlling for Grade 6 male science test scores. The null hypothesis was rejected at the 95% confidence level: $F(1,1948)=17.11$; $p<0.001$; partial $\eta^2=0.009$. The effect size was considered to be weak with a partial $\eta^2=0.009$ when interpreted in light of a 0.25 level of effect size and a statistical power of 0.5 (Gall et al., 2007; Warner, 2013). The small effect size indicated that there may be limited practical applications to the research. Because the null was rejected, the researcher conducted a Bonferroni post hoc test (Warner, 2013). School District B male science test scores were statistically significantly greater ($M_{diff}=4.28$; $SE=1.04$; 95% CI [-6.32, -2.25]; p=0.001) compared to School District A male science test scores ($M_{diff}=-4.28$; $SE=1.04$; 95% CI [2.25, 6.32]; $p=0.001$). See Table 15 for the multiple comparisons of groups.

Table 15

Multiple Comparisons of Groups

					95% Confidence Interval for Difference[b]	
(I) Computer Use	(J) Computer Use	Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
School A	School B	-4.28*	1.04	<0.001	-6.32	-2.25
School B	School A	4.28*	1.04	<0.001	2.25	6.32

Based on estimated marginal means. *The mean difference is significant at the 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni

Null Hypothesis Three

Null hypothesis three indicated that there was no difference in social studies achievement scores between Grade 7 female students on the South Carolina Palmetto Assessment of State Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 female social studies achievement scores.

Data Screening

The researcher conducted a box-and-whiskers plot for Grade 7 female social studies scores, which indicated eight outliers for School District A with one extreme outlier. An extreme outlier indicates a score that falls more than three times outside the interquartile range and is indicated by an asterisk in the SPSS output (Warner, 2013). The researcher reviewed the data for inaccuracies, and found none. There were 10 outliers for Grade 7 School District B scores. The covariate Grade 6 female social studies scores also contained 13 total outliers. The researcher checked all of the data points, which had been entered into the software correctly. The researcher kept all of the data points because the outliers can be considered genuinely unusual, and omitting them would alter the outcome (Warner, 2013). The extreme outlier can be considered an interesting outlier, or a correct data point (Aguinis et al., 2013). Additionally, the researcher kept all data points because they observed normal distribution patterns on the histograms and on the Kolmogorov-Smirnov test (Warner, 2013). When the researcher converted the outliers to standard scores, they all fell within +3 and -3 standard deviation of the sample mean (Warner, 2013, p. 153). See Figures 13 and 14 for the box-and-whisker plots of female Grade 7 and Grade 6 social studies scores for School Districts A and B.

Figure 13

Box-and-Whiskers Plot for Grade 7 Female Social Studies Scores – School Districts A and B

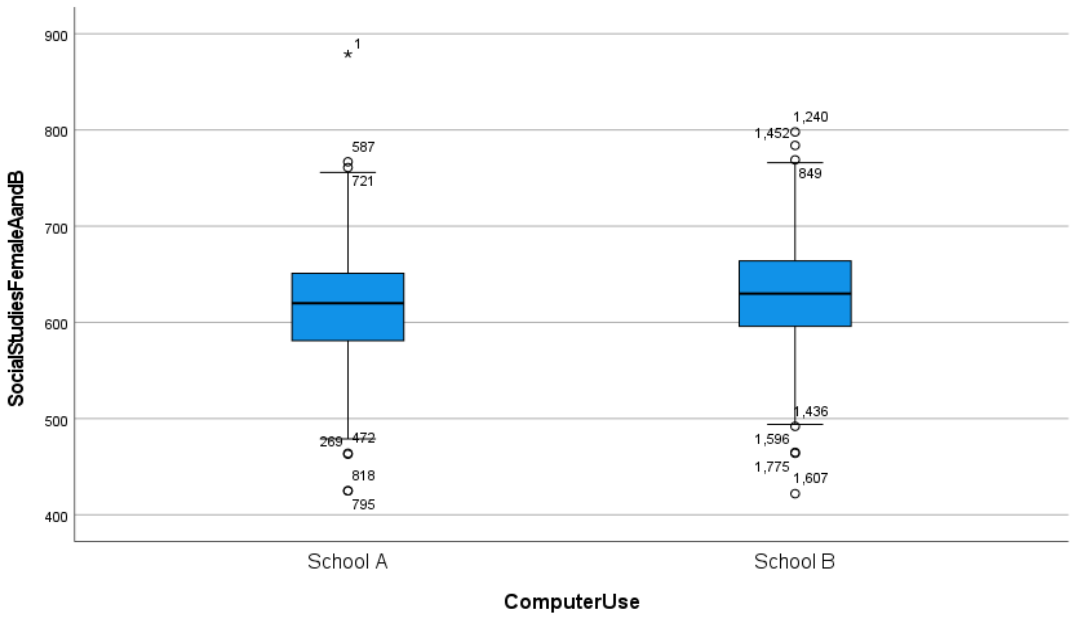
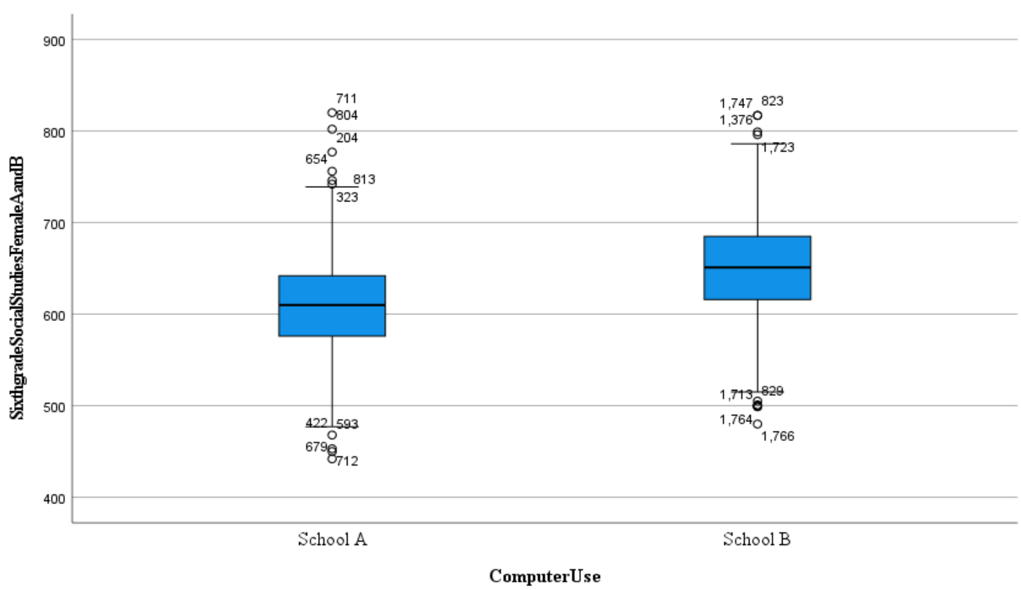


Figure 14

Box-and-Whiskers Plot for Grade 6 Female Social Studies Scores – School Districts A and B



Assumptions Testing

The researcher used an ANCOVA to test the null hypothesis, and assessed the following assumptions: normality, linearity, bivariate normal distribution, homogeneity of slopes, and the homogeneity of variance. The normality of distribution can also be tested using the Kolmogorov-Smirnov statistical analysis. The results of this statistical analysis indicated that the data did not violate the assumption of normality for either School District A or B. See Table 16 for the tests of normality.

Table 16

Tests of Normality

		Kolmogorov-Smirnov		
Groups		Statistic	*df*	Sig.
Grade 7	1 – School A	0.041	818	0.314
Female	2 – School B	0.037	977	0.200
Grade 6	1 – School A	0.031	910	0.062
Female	2 – School B	0.024	946	0.200

The researcher tested the assumption of normality next as a histogram. This assumption postulated that there should be a bell curve shape on a histogram (Rovai et al., 2014). The researcher observed normal distribution shapes for each graph. The assumption of homogeneity of regression slopes was tenable. Figures 15 and 16 show the histogram graphs for the Grade 7 and Grade 6 social studies scores from School Districts A and B.

Figure 15

Histograms of Grade 7 Female Social Studies Scores – School Districts A and B

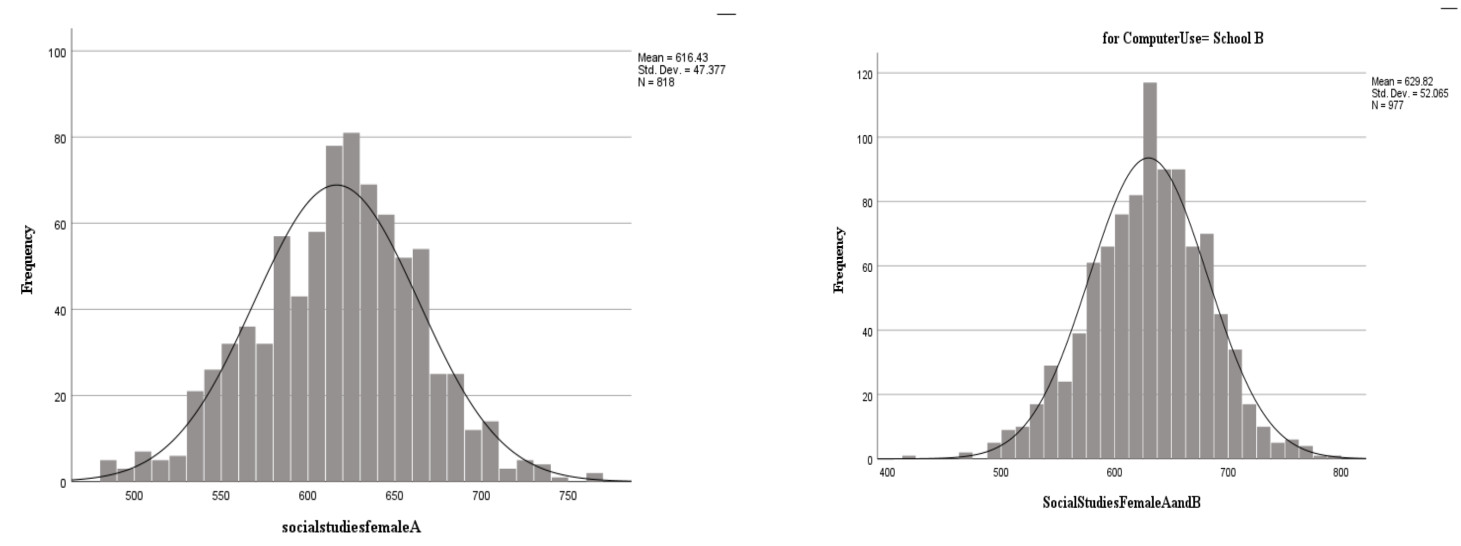
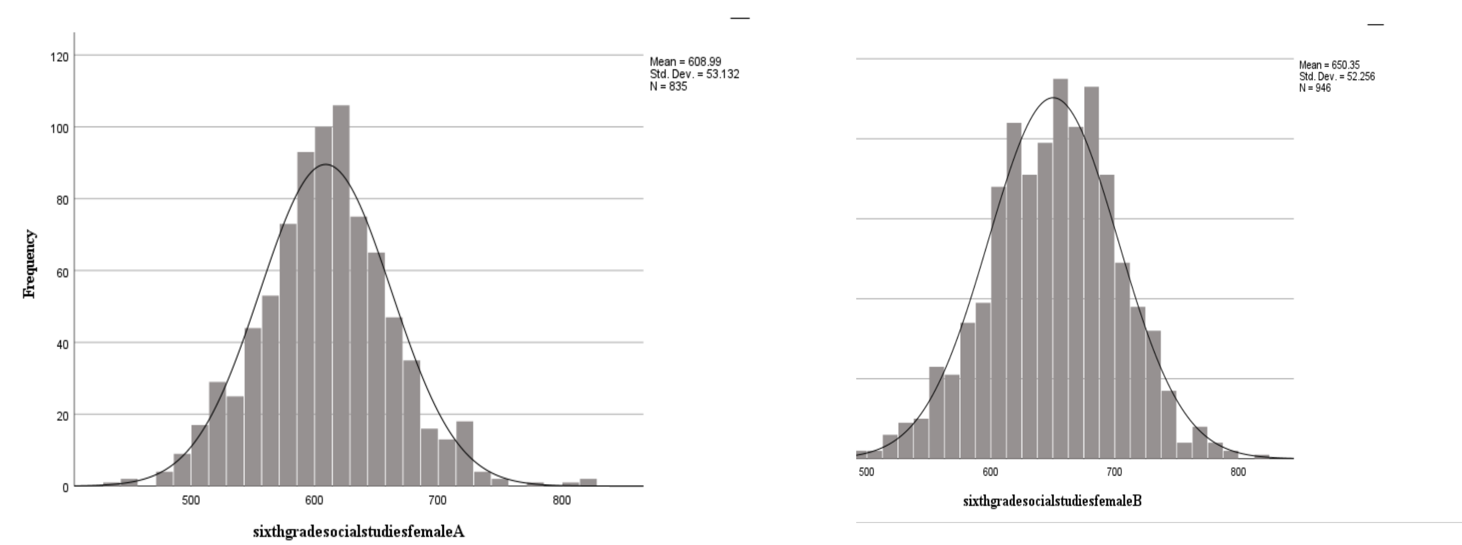


Figure 16

Histograms of Grade 6 Female Social Studies Scores – School Districts A and B



The researcher tested the assumption of linearity and bivariate normal distribution using scatter plots for each group. They also investigated the slopes of regression relationship using a scatter plot. Upon inspection, there was a linear relationship between Grade 6 and Grade 7 female social studies scores (Warner, 2013). See Figures 17 and 18 for the scatterplots of Grade 6 and 7 female social studies test scores by computer use.

Figure 17

Scatterplot of Grade 6 and 7 Female Social Studies Test Scores – School District A

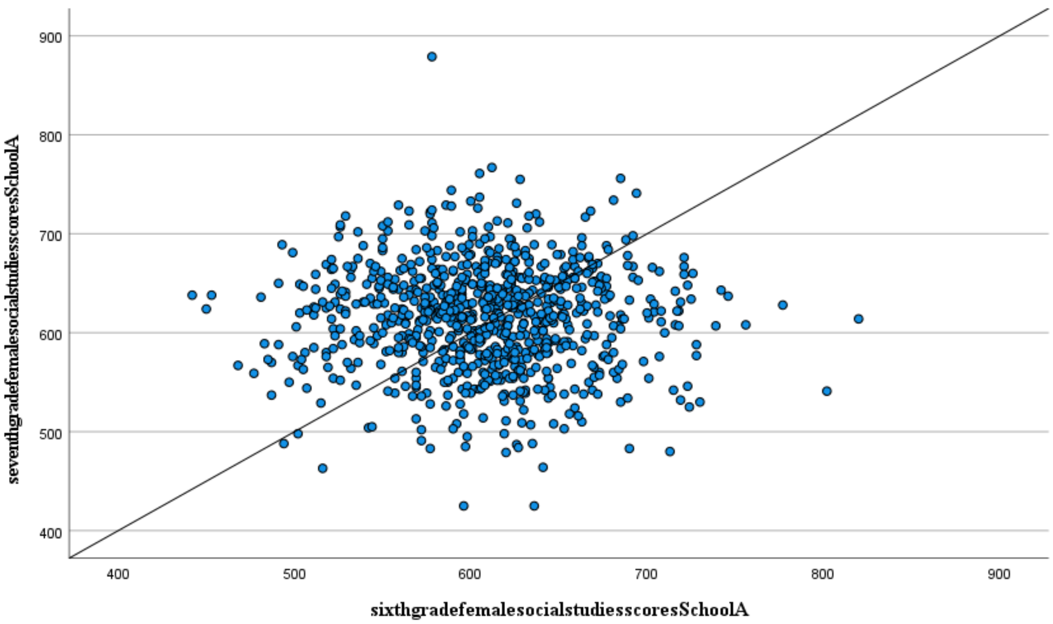
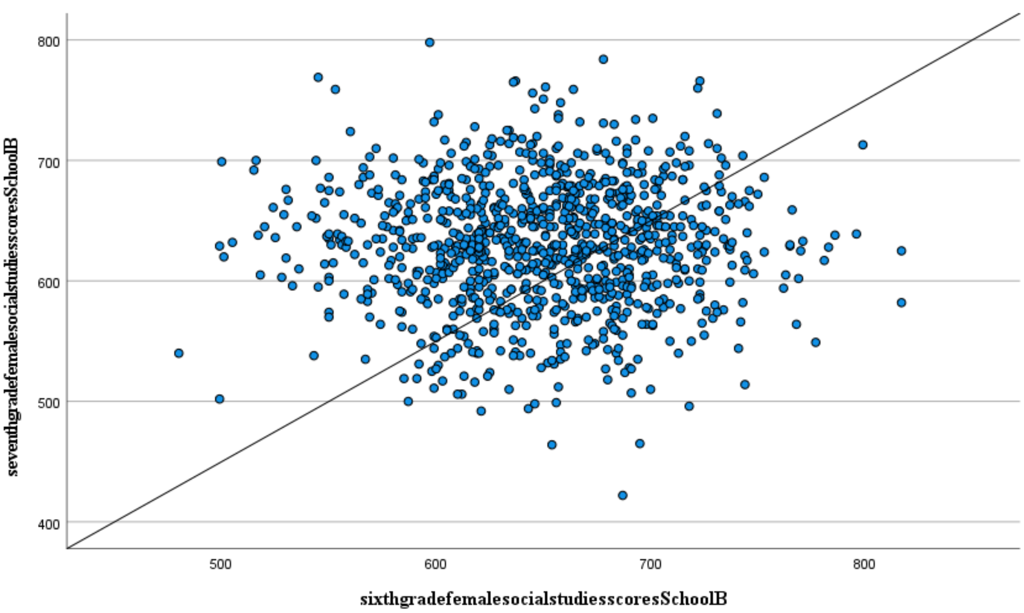


Figure 18

Scatterplot of Grade 6 and 7 Female Social Studies Test Scores – School District B



The researcher tested the assumption of homogeneity of slopes and found no interaction, where p=0.821. Therefore, the assumption of homogeneity of slope was met. As seen in Table 17, there were homogeneity of regression slopes as the interaction term was not statistically significant: $F(1,1791)=0.05$; $p=0.821$; partial $\eta^2=0.000$. See Table 17 for the results of the homogeneity of regression slopes for Grade 7 female social studies scores in School Districts A and B, with Grade 6 female social studies scores as the covariate.

Table 17

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	n^2
Corrected Model	83933.97[a]	3	27977.99	10.08	<0.001	0.017
Intercept	4990987.87	1	4990987.87	1798.30	<0.001	0.501
Computer Use	176.55	1	176.55	0.06	0.801	0.000
Grade 6 Social Studies Female A and B	1183.90	1	1183.90	0.43	0.514	0.000
Computer Use* Grade 6 Social Studies Female A and B Scores	141.81	1	141.81	0.05	0.821	0.000
Error	4970727.71	1791	2775.39			
Total	703118738.00	1795				
Corrected Total	5054661.68	1794				

Note. [a.] R Squared=0.009 (Adjusted R Squared=0.007)

The researcher then analyzed the homogeneity of variance. This assumption tests the variance within each population. To test this assumption, the researcher conducted the Levene's test, $F(1,1793)=0.42$. As the test results indicated ($p=0.517$), homogeneity of variance was present. The assumption of homogeneity of variance was met.

Results for Null Hypothesis

The researcher used an ANCOVA to test the differences between Grade 7 female social studies test scores for students who used one-to-one technology and Grade 7 female students who did not, while controlling for Grade 6 female social studies test scores. The null hypothesis was rejected at the 95% confidence level: $F(1,1792)=28.31$; $p<.001$; partial $\eta^2=0.016$. The effect size was considered to be weak with a partial $\eta^2=0.016$ when interpreted in light of a 0.25 level of effect size and a statistical power of 0.5 (Gall et al., 2007; Warner, 2013). The small effect size indicated there may be limited practical applications to the research. Because the null was rejected, the researcher conducted a Bonferroni post hoc test (Warner, 2013). School District B female social studies test scores were statistically significantly greater ($M_{diff}=14.24$; $SE=2.68$; 95% *CI* [8.00, 19.49]; $p=0.001$), compared to School District A female social studies test scores ($M_{diff}=-14.24$; $SE=2.68$, 95% *CI* [-19.49, -8.99]; $p=0.001$). See Table 18 for the multiple comparisons of groups.

Table 18

Pairwise Comparisons of Female Social Studies Test Scores

					95% Confidence Interval for Difference[b]	
(I) Computer Use	(J) Computer Use	Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
School A	School B	-14.24	2.68	<0.001	-19.49	-8.99
School B	School A	14.24	2.68	<0.001	8.99	19.49

Based on estimated marginal means.
*The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni

Null Hypothesis Four

Null hypothesis four indicated that there was no difference in social studies achievement scores between Grade 7 male students on the South Carolina Palmetto Assessment of State

Standards (SCPASS) who had access to one-to-one technology in the classroom and students who did not, when controlling for Grade 6 male social studies achievement scores.

Data Screening

To test for the assumption of normality, the researcher conducted a box-and-whiskers plot for Grade 6 and Grade 7 male social studies scores. The researcher reviewed the data for inaccuracies and found none. For the Grade 7 scores, there were a total of 14 outliers. The covariate Grade 6 male social studies scored contained 10 outliers. The researcher checked all of the data points and concluded that they had been entered into the software correctly. The researcher kept all of the data points because omitting any outliers would alter the outcome. There were normally distributed shapes for the data on the histograms and on the Shapiro-Wilk test (Warner, 2013). Moreover, converting the outliers to standard scores revealed that all fell within +3 and -3 standard deviation of the sample mean (Warner, 2013, p. 153). See Figures 19 and 20 for the box-and-whiskers plots for Grade 7 and Grade 6 male social studies scores.

Figure 19

Box-and-Whiskers Plot for Grade 7 Male Social Studies Scores – School Districts A and B

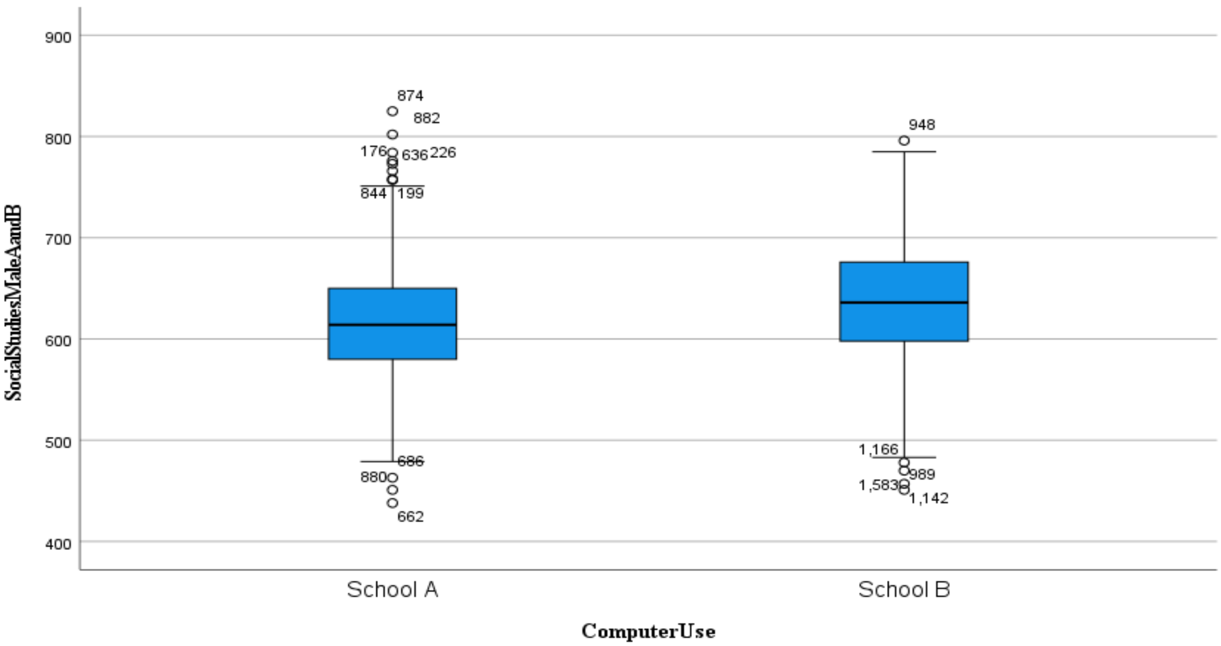
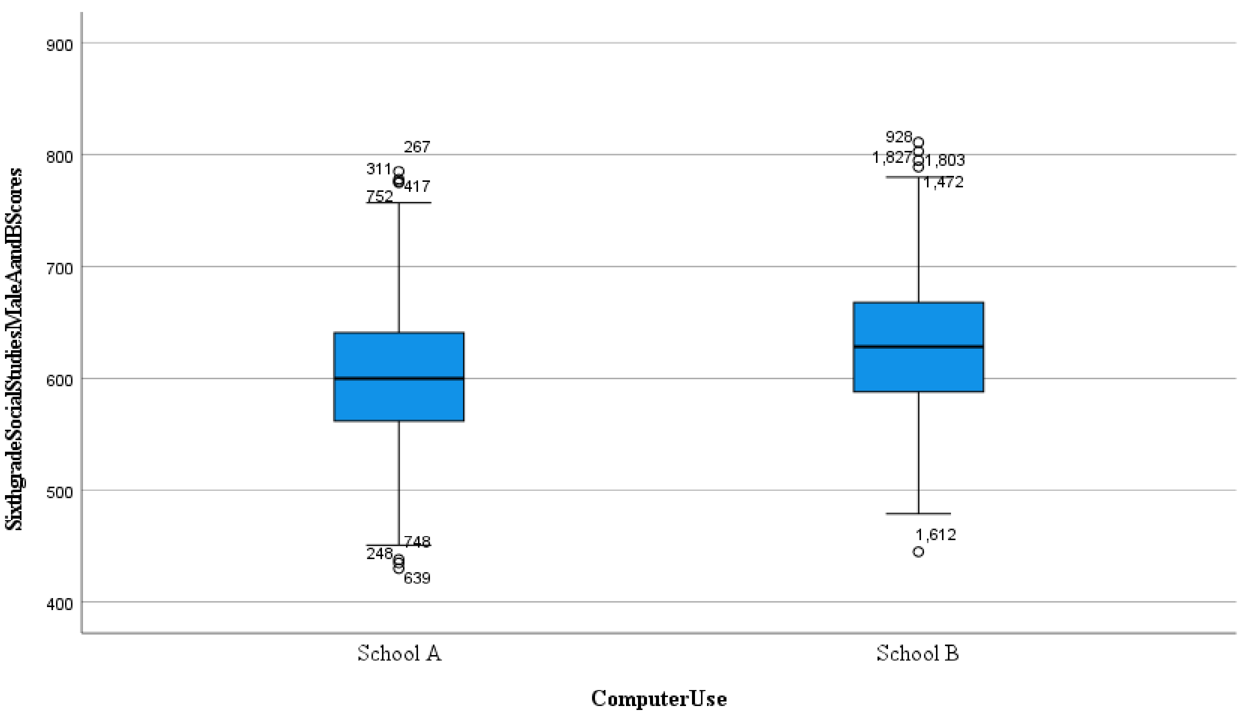


Figure 20

Box-and-Whiskers Plot for Grade 6 Male Social Studies Scores – School Districts A and B



Assumptions Testing

The researcher used an ANCOVA to test the null hypothesis and assessed the following assumptions: normality, linearity, bivariate normal distribution, homogeneity of slopes, and the homogeneity of variance. The assumption of normality for an ANCOVA postulates that the population sample is normal and fits a bell curve. The Kolmogorov-Smirnov statistical analysis can also test for the normality of the distribution (Warner, 2013). This statistical analysis indicated that the data did not violate the assumption of normality for either School District A or B. The assumption of normality was met. See Table 19 for the tests of normality.

Table 19

Tests of Normality

		Kolmogorov-Smirnov		
Groups		Statistic	*df*	Sig.
Grade 7	1 – School A	0.029	882	0.074
Males	2 – School B	0.026	1,069	0.091
Grade 6	1 – School A	0.020	835	0.200
Males	2 – School B	0.882	1,060	0.200

The assumption of normality assumes that there should be a bell curve shape on a histogram (Rovai et al., 2014). The researcher observed normal distribution shapes for each graph. See Figures 21 and 22 for the Grade 7 and Grade 6 histograms of male social studies scores for School Districts A and B.

Figure 21

Histograms of Grade 7 Male Social Studies Scores – School Districts A and B

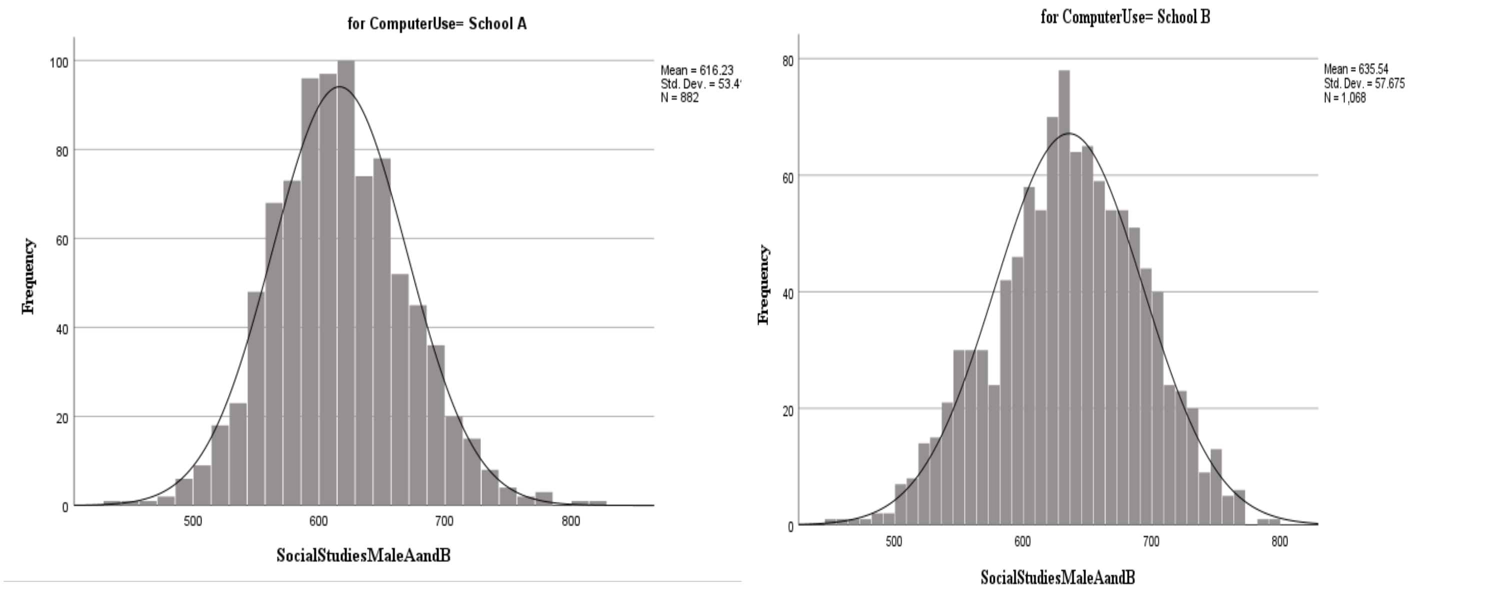
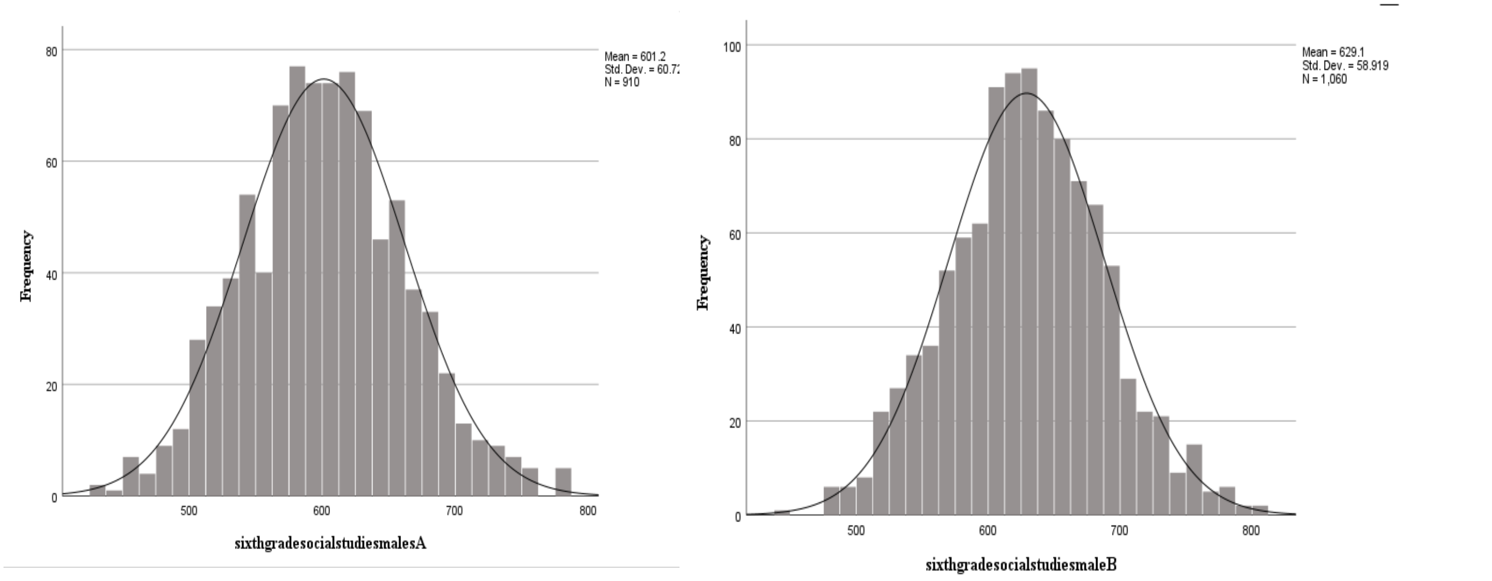


Figure 22

Histograms of Grade 6 Male Social Studies Scores – School Districts A and B



The researcher tested the assumption of linearity and bivariate normal distribution using scatter plots for each group. They also investigated the slopes of regression relationship using a scatter plot. Upon inspection, there was a linear relationship between Grade 6 and 7 male social studies scores (Warner, 2013). See Figures 23 and 24 for the scatterplots of Grade 6 and 7 male social studies test scores by computer use.

Figure 23

Scatterplot of Grade 6 and 7 Social Studies Test Scores – School District A

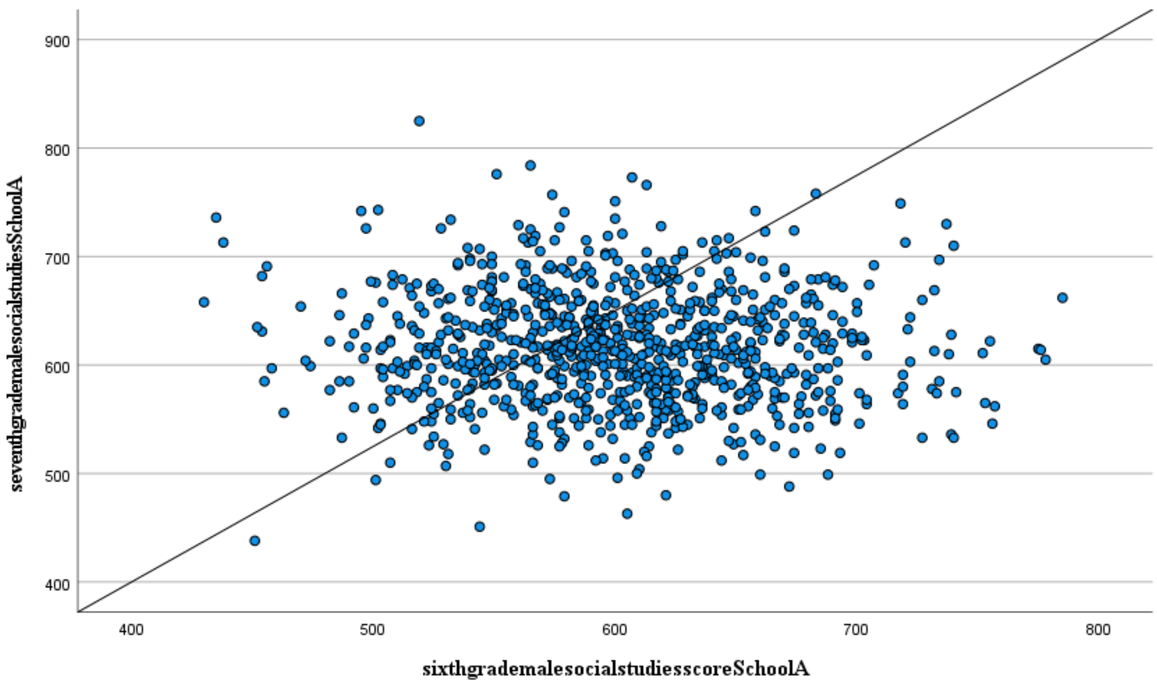
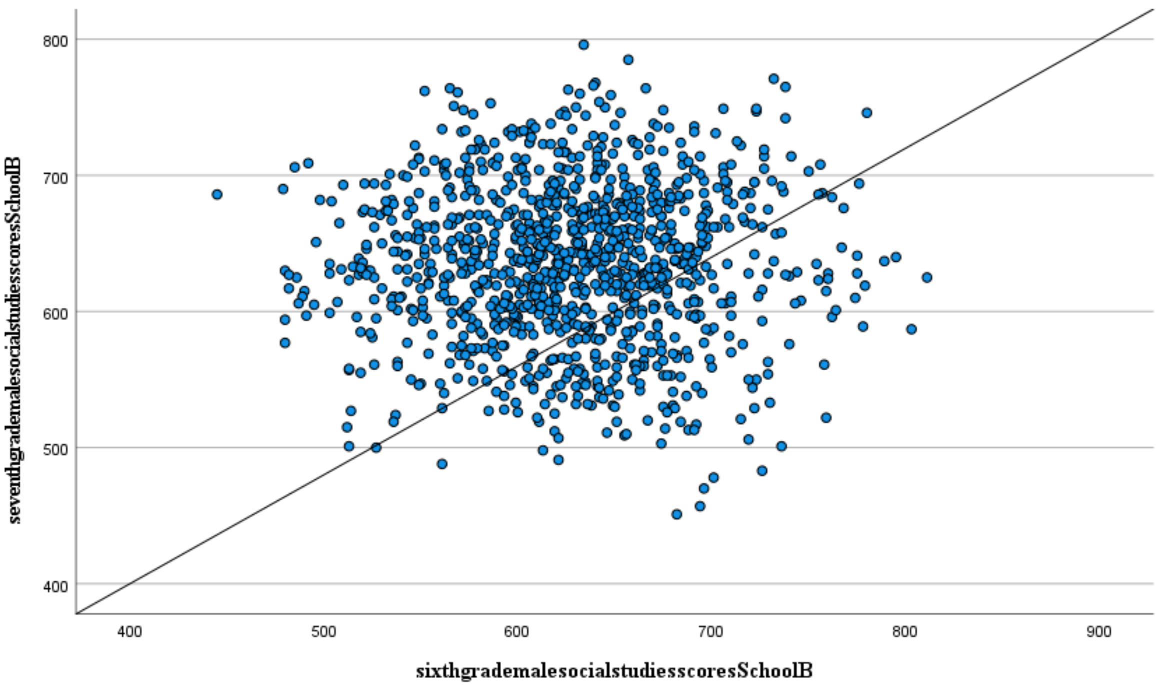


Figure 24

Scatterplot of Grade 6 and 7 Social Studies Test Scores – School District B



The researcher tested the assumption of homogeneity of slopes and found no interaction, where *p*=0.240. Therefore, the assumption of homogeneity of slope was met. As seen in Table 20, the regression slopes were homogeneous as the interaction term was not statistically significant: *F*(1,1947)=0.16; *p*=0.686. The researcher deemed the assumption of homogeneity of regression slopes to be tenable. As seen in Table 20, the regression slopes were homogeneous as the interaction term was not statistically significant: *F*(1,1946)=4.38; *p*=0.240. The assumption of homogeneity of regression slopes was tenable. See Table 20 for the homogeneity of regression slopes for Grade 7 male social studies scores in School Districts A and B, with Grade 6 male social studies scores as the covariate.

Table 20

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	n^2
Corrected Model	186035.09[a]	3	62011.70	19.92	<0.001	.030
Intercept	7339335.69	1	7339335.69	2358.14	0.000	0.548
Computer Use	543.99	1	543.99	0.18	0.676	0.000
Grade 6 Social Studies Male A and B Scores	2193.32	1	2193.32	0.71	0.401	0.000
Computer Use* Grade 6 Social Studies Male A and B Scores	4305.29	1	4305.29	4.38	0.240	0.001
Error	6056625.63	1946	3112.35			
Total	772370272.00	1950				
Corrected Total	6242660.73	1949				

Note. [a.] *R* Squared=0.030 (Adjusted *R* Squared=0.028)

The next assumption involved the homogeneity of variance. This expectation was one in which the independent variable (use of one-top-one technology) would affect the means of the covariate (Grade 6 social studies male scores) and the dependent variable (Grade 7 social studies male scores). To test this assumption, the researcher conducted Levene's test: $F(1,1948)=7.34$. As the results of the test indicated ($p=0.08$), homogeneity of variance was present, and the assumption was met.

Results for Null Hypothesis

The researcher used an ANCOVA to test the differences between Grade 7 male social studies test scores for students who used one-to-one technology and Grade 7 male students who did not, while controlling for Grade 6 male social studies test scores. The null hypothesis was rejected at the 95% confidence level: $F(1,1947)=57.54$; $p<0.001$; partial $\eta^2=0.029$ The effect size was considered to be weak with a partial $\eta^2=0.029$ when interpreted in light of a 0.25 level of effect size and a statistical power of 0.5 (Gall et al., 2007; Warner, 2013). The small effect size indicated that there may be limited practical applications to the research. Because the null was rejected, the researcher conducted a Bonferroni post hoc test (Warner, 2013). School District B male social studies test scores were statistically significantly greater ($M_{diff}=19.72$; $SE=2.60$; 95% CI [14.62, 24.82]; $p=<0.001$), compared to School District A male social studies test scores ($M_{diff}=-19.72$; $SE=2.60$; 95% CI [-24.82, -14.62]; $p=<0.001$. See Table 21 for the multiple comparisons of groups.

Table 21

Pairwise Comparisons of Male Social Studies Test Scores

					95% Confidence Interval for Difference[b]	
(I) Computer Use	(J) Computer Use	Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
School A	School B	-19.72	2.60	<0.001	-24.82	-14.62
School B	School A	19.72	2.60	<0.001	14.62	24.82

Based on estimated marginal means. *The mean difference is significant at the 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter discusses how the research findings from this study relate to the existing body of literature. It revisits Bruner's (1966) and Vygotsky's (1978) theoretical frameworks and discusses them in terms of the research question and null hypotheses. Chapter Five also presents additional outcomes found in the study and their implications. It then concludes with a discussion of the study' limitations and recommendations for future research.

Discussion

This study sought to determine if using one-to-one technology in Grade 7 increased academic achievement on state test exams in science and social studies. The exam scores of two school districts were used to test the hypotheses, and the data was based on 3,747 Grade 7 test scores. The independent variable for this study was the use of one-to-one technology, and the dependent variables were the achievement scores in science and social studies. In addition, the covariate was the Grade 6 scores on the SCPASS exam in science and social studies.

Research Question 1

The findings supported rejecting the null hypothesis in RQ1, which asked if there were any significant differences in SCPASS science exam scores for female students who used one-to-one technology and the science exam scores of female students who did not use one-to-one technology. The researcher conducted an ANCOVA, and the results indicated that there were significant differences in test scores between the types of technology used for SCPASS test scores in science for female students: $F(1,1793)=9.56$; $p=0.002$; partial $\eta^2=0.005$. With the alpha level set to 0.05, anything less than this indicates a significant difference (Warner, 2013). The average scores for female students in Grade 7 for School District B, which did not use one-to-one technology, were higher (M=1,752) on the SCPASS exam in science than female students in School District A (M=1,749). The researcher performed a post hoc analysis with a Bonferroni correction process of adjusting the alpha level for the statistical test. For this study, $EW\alpha=0.05$, and there were four analyses (k=4). The researcher used the equation $PC\alpha=EW\alpha/k=0.0125$. The results of this test indicated significant differences in female science achievement scores, considering p=0.003. These results suggest that one-to-one technology did not contribute to higher science achievement grades in School District A compared to School District B, holding Grade 6 achievement scores as the covariate.

Female students in both school districts scored higher on the Grade 7 science SCPASS assessment than their male peers. The results of this study align with a study conducted by Patterson and Patterson (2017), which investigated common concerns regarding computer use in the classroom, such as providing distractions and opportunities for students to cyberslack. Patterson and Patterson (2017) studied a population of 14 college classrooms with an option to use a computer or not to use one, with n=229 participants. The results indicated that computer use decreased course grades between 0.14 and 0.37. The study also concluded that there were more negative effects of using one-to-one technology for males than for females (Patterson & Patterson, 2017).

However, the use of one-to-one technology may still influence student engagement and interest. The driving force behind providing students with one-to-one technology is that they develop the skills they need to be productive and contributing members of the 21st-century workforce. Interest in digital literacy and STEM subjects for females begins in the primary grades and rapidly declines through the secondary grades (Gorbacheva, 2020). The declining interest in these subjects may be preventable if education is tailored to females’ specific needs

(Happe et al., 2020). Increasing female student interest in STEM subjects would help close the "leaky pipeline" and provide these fields with more experts that can contribute to today's advanced technological workforce in meaningful ways.

Research Question 2

The findings supported rejecting the null hypothesis in RQ2, which asked if there were any significant differences in SCPASS science exam scores for male students who used one-to-one technology and male student scores on the science exam who did not use one-to-one technology. The researcher conducted an ANCOVA, and the results indicated significant differences in test scores between the types of technology used for SCPASS test scores in science for male students: $F(1,1948)=17.11$; $p<0.001$; partial $\eta^2=0.009$. Anything less than an alpha level of 0.05 indicates a significant difference (Warner, 2013). The average scores for male students in Grade 7 for School District B, which did not use one-to-one technology, were higher (M=1,751) on the SCPASS exam in science than those of the male students in School District A (M=1,746). The researcher performed a post hoc analysis with a Bonferroni correction process of adjusting the alpha level for the statistical test. For this study, EWα=0.05, and there were four analyses (k=4). The researcher used the equation PCα=EWα/k=0.0125. The results of this test indicated significant differences in female science achievement scores, considering p=<0.001. These results suggest that one-to-one technology did not contribute to higher male science achievement grades in School District A, holding for Grade 6 male science achievement scores as the covariate.

There may be several reasons why achievement scores for schools using to one-to-one technology do not live up to the expectation that this technology increases student knowledge. Implementing new technology is challenging for educators in terms of classroom management, the need to develop and learn new teaching methods, and to offer additional and specific professional development (Keane et al., 2020). Some studies suggest that if using technology does not affect academic outcomes in a classroom, it may be because using one-to-one technology does not bring about meaningful change in a teacher's learning and teaching beliefs (Hershkovitz & Karni, 2018). Teachers must buy into the implementation of technology in their classrooms so that they use the pedagogical practice of one-to-one technology to the fullest potential.

Research Question 3

RQ3 for this study asked if there were any significant differences in SCPASS social studies exam scores for female students who used one-to-one technology and the social studies exam scores of female students who did not use one-to-one technology. The findings supported rejecting the null hypothesis. The researcher conducted an ANCOVA, and the results indicated that there were significant differences in test scores between the types of technology used for SCPASS test scores in social studies for female students: $F(1,1792)=28.31$; $p<0.001$; partial $\eta^2=0.016$. With the alpha level set to 0.05, anything less than that value indicates a significant difference (Warner, 2013). The average scores for female students in Grade 7 for School District B were higher (M=629.8) on the SCPASS exam in social studies than those for female students in School District A, which used one-to-one technology (M=616.4). The researcher performed a post hoc analysis with a Bonferroni correction process of adjusting the alpha level for the statistical test. For this study, EWα=0.05 and there were four analyses (k=4). The researcher used the equation PCα=EWα/k=0.0125. The results of this test indicated that there were significant differences in female social studies achievement scores, considering that p=<0.001. These results suggested that the use of one-to-one technology did not contribute to higher female social studies achievement grades in School District A, holding Grade 6 female social studies achievement scores as the covariate.

Of the two Grade 7 test subject comparisons, the only tests in which boys outscored girls, or scored as well as girls, were in the area of social studies. This is interesting to note because it indicates research on whether one-to-one technology increases achievement for males or females continues to produce mixed results (Angrist & Lavy, 2002). Lowther et al. (2012) studied Grade 7 student test scores using the Michigan Educational Assessment Program (MEAP) scores, comparing students who participated in the Freedom to Learn (FTL) one-to-one laptop initiative and students who did not participate in the initiative. The mixed-methods, quasi-experimental study reported that across the subjects of English, mathematics, reading, and writing, there were no significant differences between female or male students who used one-to-one technology and those who did not. Lowther et al. (2012) concluded there were no positive impacts of using laptops on students' state test scores.

Research Question 4

RQ4 for this study asked if there were any significant differences in SCPASS social studies exam scores for male students who used one-to-one technology and male students on the social studies exam who did not use one-to-one technology, and the findings supported rejecting the null hypothesis. The researcher conducted an ANCOVA, and the results indicated that there were significant differences in test scores between the types of technology used for SCPASS test scores in social studies for male students: $F(1,1947)=57.54$; $p < 0.001$; partial $\eta^2=0.029$. With the alpha level set to 0.05, anything less than that value indicates a significant difference (Warner, 2013). The average scores for male students in Grade 7 for School District B were higher (M=635.5) on the SCPASS exam in social studies than those of male students in School District

A, which used one-to-one technology (*M*=616.2). The researcher performed a post hoc analysis with a Bonferroni correction process of adjusting the alpha level for the statistical test. For this study, $EW\alpha=0.05$, and there were four analyses (k=4). The researcher used the equation $PC\alpha=W\alpha/k=0.0125$. The results of this test indicated significant differences in male social studies achievement scores, considering that p=<0.001. These results suggested that the use of one-to-one technology did not contribute to higher social studies achievement grades in School District A, holding Grade 6 social studies achievement scores as the covariate.

In contrast to the results of this current study, the extant literature reveals positive correlations between academic achievement and the use of one-to-one technology. One longitudinal study compared the scores in reading and math for students at 21 middle schools in Texas that used one-to-one technology with the scores of students from 21 middle schools that did not provide the same technology. The study examined the scores over a 3-year span and used the Texas Assessment of Knowledge and Skills (TAKS) as the instrument. The researchers reported positive effects on the students' test scores, but these were not statistically significant (Shapley et al., 2011). Another research study conducted in central Illinois investigated whether there were academic gains for two Grade 4 classrooms that used one-to-one technology. Using a Discovery Education math assessment, Harris et al. (2016) reported higher scores for the students who used one-to-one technology in the classroom than those who did not use one-to-one technology. These studies seem to contradict the results of the current study, but neither of them produced significant statistical results that definitely provide proof that using one-to-one technology increases test scores.

Theoretical Framework

The theoretical frameworks that supported this study included Vygotsky's zone of proximal development (ZPD) and Bruner's theory of scaffolding. Both theories are categorized under the umbrella of constructivism, and they each emphasize active and social learning. Vygotsky believed that the ZPD is the distance between a student's actual development level and his or her potential level (Vygotsky, 1978). Vygotsky also postulated that teaching and learning were collaborative activities, and that creativity specifically is a social process that requires appropriate tools (Daniels, 2016). Computers can be seen as educational tools that have the potential to allow for collaboration among students, teachers, and peers. To Vygotsky, there were unique relationships between learning scientific processes and an educational object. Children must be allowed to work collaboratively with scientific objects, Vygotsky postulated, because they can do more by working with others than they can by working independently (Daniels, 2016; Vygotsky, 2004). Current research supports the use of one-to-one technology as a tool that can provide the support students need to reduce the gap between their current level of knowledge and what they need to learn new information or skills (Jaakkola & Nurmi, 2008; Kozma, 2003; Linn & Eylon, 2011).

Many of the personal computing devices school districts provide today contain digital tools that provide gradual support initially and then slowly remove the support when the student no longer needs the additional guidance. This is called scaffolding, and Bruner based this theory on Vygotsky's ZPD. Scaffolded support is especially helpful in the laboratory setting, where students encounter many open-ended problems to solve (Clark & Mahboobin, 2018). The use of simulation software and tools, virtual labs, and the ability to create diagrams and graphs are all types of scaffolding support students need to succeed in STEM classes (Furberg, 2016). Despite the high-tech nature of using one-to-one technology, many researchers believe that students will continue to need feedback from teachers and peers so that they may learn most effectively (Furberg, 2016; Zheng et al., 2022).

Implications

This study suggested that one-to-one technology can impact standardized test scores in science and social studies. Students who did not use one-to-one technology scored higher on state assessments than students who did use one-to-one technology. One implication gleaned from this research is that providing one-to-one technology can provide distractions for students, especially males. This may explain why females scored higher than males on all assessments in this study, except on Grade 7 social studies in School District B. Recently, Wu and Cheng (2019) examined gender differences in male and female perceived attention problems (PAP) and found that males exhibited higher PAP than females. According to Glass and Kang (2019), dividing attention between an electric device and classroom instruction does not reduce short-term instruction but long-term retention.

Digital natives, or children born into a digitally rich environment in the early 21st century, have reported feeling more confident that they can multitask while using technology in the classroom (Jayman & Ohl, 2021). However, research shows that the more students multitask, the lower their grade performance. Multitasking may be a myth, as additional studies show that a human brain can only pay attention to one subject at once (Berdik, 2018). Being distracted by social applications and websites using one-to-one technology creates another set of issues. Empirical data indicates that the more students engage in social media, the lower their self-esteem and learning performance (Wu & Cheng, 2019). However, it is also important to note that digital distractions do not end when school begins for the day and that managing them is now a new life skill.

It is also important to highlight that there are multicultural and socio-economic differences between School District A and School District B, which may have affected the study findings. There was a higher percentage of students identified as students in poverty (SIP) in School District A (72.3%) compared to students in School District B (41.5%). Studies on gaps in socioeconomic status (SES) between students of lower income and their peers commonly report that students from low SES backgrounds score lower on achievement tests and attain less education than their peers (Albert et al., 2020; Chmielewski, 2019). Explanations of the gap include inequities in income and parental investment and increased school choice (Chmielewski, 2019). Students from low SES backgrounds are also more likely to have low parental education and to not receive the same learning opportunities as students of high socioeconomic status (Albert et al., 2020; Chmielewski, 2019). With regards to technology, students from high incomes are more likely to learn in a digitally rich environment and have the technology for use at home. There has been a concerted effort within lower-income school districts to provide technology for students in order to bridge the academic achievement gap (Chmielewski, 2019).

There is still no clear answer as to whether using one-to-one technology has positive benefits in the classroom. Exacerbated by the global pandemic, there has been an educational reform movement that believes that students should learn computer skills and computer literacy. The old pedagogical philosophy that stated that educators should select the most appropriate tools at hand that are best suited for student learning seems to be fading away. In its place is a new philosophy that insists that all instruction should use one-to-one technology simply because the tool exists (Horvath, 2020).

Limitations

The discussion of study limitations is an important part of the scientific process (Puhan et al., 2012). For this study, there was a time restriction regarding school years for the use of one-to-one technology. In South Carolina in 2016-2017, before the pandemic, some schools chose to adopt one-to-one technology, and others did not; it was optional for school districts to adopt technology initiatives that provided laptops for each student. Once the pandemic began closing schools, school districts needed to provide technology for students to learn from home.

This study also had limitations in sample size and population demographics. The researcher compared only two school districts, and the sample size was not the same for each district. The sample was considered one of convenience because the populations were predetermined before the study began (Gall et al., 2007). The samples differed in student ethnicity and socio-economic status. There were also different numbers of students who classified for special education services and who were Limited English Proficient (LEP). Since the test groups were not randomized, there may have been an overrepresentation or underrepresentation of specific populations of students.

The researcher used a causal-comparative design for this study. It was also non-experimental. There are inherent design limitations in causal-comparative studies. One limitation is that the independent variables cannot be manipulated (Creswell & Creswell, 2018; Gall et al., 2007). The researcher also could not randomly assign participants to various groups. Since this study used a restricted sample of two school districts in South Carolina, it is difficult to generalize the results for an entire population (Salkind, 2010).

Another limitation is the evidence of an outlier in the Grade 7 female social studies SCPASS scores. However, negatively defining outliers often leads to removing them, and this can result in artificial range restriction and affect outcomes (Warner, 2013). For this study, the outlier was considered to be an interesting outlier. Interesting outliers are data points that are accurate but that are not confirmed as actual error outliers (Aguinis et al., 2013).

Lastly, there were differences in teacher training between the school districts. The researcher did not know to what extent or how long teachers in School Districts A and B attended training to use one-to-one technology. Not all school districts provide the same number of technology training hours, and this can be problematic in the classroom (Hull & Duch, 2019). The number of hours that School District A used computers during the 2016-2017 school year was also not reported. Increased use of technology in a classroom has been tied to teacher training and feelings of technology self-efficacy for educators (Topper & Lancaster, 2013).

Recommendations for Future Research

The researcher believed that this study is a valuable addition to the extant literature that quantitatively measures the benefits of using one-to-one technology. There are several recommendations to expand the knowledge in this field. This study could include additional grade levels and different subjects other than science and social studies. This study could also be replicated in additional geographical areas, since it was conducted in only two South Carolina school districts. To extend the generalizability of the study results, future research can analyze how much time students spend using one-to-one technology specifically and if that leads to any differences in academic achievement. Researchers must study one-to-one technology's effect on academic achievement over a longer period of time. This study only used 1 year of data. Schools may typically take 3 to 5 years to implement and produce stable outcomes (Shapley et al., 2011). Lastly, it is recommended that other achievement instruments be used to study how and to what extent using one-to-one technology has an impact on student achievement.

REFERENCES

Agarkar, S. C. (2019). Influence of learning theories on science education. *Resonance*, *24*(8), 847–859. https://doi.org/10.1007/s12045-019-0848-7

Aguilar-Roca, N. M., Williams, A. E., & O'Dowd, D. K. (2012). The impact of laptop-free zones on student performance and attitudes in large lectures. *Computers and Education*, *59*(4), 1300–1308. https://doi.org/10.1016/j.compedu.2012.05.002

Aguinis, H., Gottfredson, R. K., & Joo, H. (2013). Best-practice recommendations for defining, identifying, and handling outliers. *Organizational Research Methods*, *16*(2), 270–301. https://doi.org/10.1177/1094428112470848

Albert, W. D., Hanson, J. L., Skinner, A. T., Dodge, K. A., Steinberg, L., Deater-Deckard, K., Bornstein, M. H., & Lansford, J. E. (2020). Individual differences in executive function partially explain the socioeconomic gradient in middle-school academic achievement. *Developmental Science*, *23*(5), e12937-n/a. https://doi.org/10.1111/desc.12937

An, Y., Kaplan-Rakowski, R., & Yang, J. (2021). Examining K-12 teachers' feelings, experiences, and perspectives regarding online teaching during the early stage of the COVID-19 pandemic. *Education Technology Research Development*, *69*, 2589–261. https://doi-org.ezproxy.liberty.edu/10.1007/s11423-021-10008-5

Angrist, J., & Lavy, V. (2002). New evidence on classroom computers and pupil learning. *The Economic Journal*, *112*(482), 735–765. https://doi.org/10.1111/1468-0297.00068

Appleby, D. (1986). Déjà vu in the classroom. *Network*, *4*(8).

Bachtold, M. (2013). What do students "construct" according to constructivism in science education? *Research in Science Education*, *43*(6), 2477–2496. https://doi.org/10.1007/s11165-013-9369-7

Ball, C., Huang, K., Francis, J., Kadylak, T., & Cotten, S. R. (2020). A call for computer recess: The impact of computer activities on predominantly minority students' technology and application self-efficacy. *The American Behavioral Scientist*, *64*(7), 883–899. https://doi.org/10.1177/0002764220919142

Ballen, C. J., Wieman, C., Salehi, S., Searle, J. B., & Zamudio, K. R. (2017). Enhancing diversity in undergraduate Science: Self-efficacy drives performance gains with active learning. *CBE—Life Sciences Education*, *16*(4). https://doi-org.ezproxy.liberty.edu/10.1187/cbe.16-12-0344

Bandura, A. (2002). Growing primacy of human agency in adaptation and change in the electronic age. *European Psychologist*, *7*, 2–16. https://doi.org/10.1027//1016-9040

Barak, M. (2017). Science teacher education in the twenty-first century: A pedagogical framework for technology-integrated social constructivism. *Research in Science Education*, *47*(2), 283–303. https://doi:10.1007/s11165-015-9501-y

Bas, G. (2016). The effect of multiple intelligences theory-based education on academic achievement: A meta-analytic review. *Educational Sciences: Theory and Practice*, *16(*6), 1833–1864. https://doi:10.12738/estp

Baviskar 1, S. N., Hartle, R. T., & Whitney, T. (2009). Essential criteria to characterize constructivist teaching: Derived from a review of the literature and applied to five constructivist-teaching method articles. *International Journal of Science Education*, *31*(4), 541–550. https://doi.org/10.1080/09500690701731121

Belland, B. R., Walker, A. E., Kim, N. J., & Lefler, M. (2017). Synthesizing results from empirical research on computer-based scaffolding in STEM education: A meta-analysis.

Review of Educational Research, *87*(2), 309–344. https://doi.org/10.3102/0034654316670999

Belland, B. R., Axelrod, D., & Kim, N. J. (2018). Scaffolding for optimal challenge in K-12 problem-based learning. *Interdisciplinary Journal of Problem-Based Learning, 13*(1). https://doi.org/10.7771/1541-5015.1712

Berdik, C. (2018). Dealing with digital distraction. *The Education Digest*, *84*, 40–45.

Björkvall, A., & Engblom, C. (2010). Young children's exploration of semiotic resources during unofficial computer activities in the classroom. *Journal of Early Childhood Literacy*, *10*(3), 271–293. https://doi.org/10.1177/1468798410372159

Blau, I., Peled, Y., & Anat Nusanc, A. (2015). Technological, pedagogical, and content knowledge in one-to-one classroom: Teachers developing "digital wisdom." *Interactive Learning Environment*, *24*(6). https://doi.org/10.1080/10494820.2014.978792

Blazar, D., Heller, B., Kane, T. J., Polikoff, M., Staiger, D. O., Carrell, S., Goldhaber, D., Harris, D. N., Hitch, R., Holden, K. L., & Kurlaender, M. (2020). Curriculum reform in the common core era: Evaluating elementary math textbooks across six U.S. states. *Journal of Policy Analysis and Management*, *39*(4), 966–1019. https://doi.org/10.1002/pam.22257

Boyles, D. (2020). *John Dewey's imaginative vision of teaching: Combining theory and practice*. Myers Education Press.

Breiner, J. (2016). Do we have a STEM crisis in America? S*chool Science and Mathematics*, *116*(3), 113–115. https://doi:10.1111/ssm.12167

Brandon, S., & Florence, M. (2016). Perceived implementation barriers of a one-to-one computing initiative in a large urban school district: A qualitative approach. *I-Manager's Journal on School Educational Technology*, *11*(4), 26. https://doi.org/10.26634/jsch.11.4.6010

British Educational Suppliers Association (BESA). (2016). "Significant pressure" on schools' tech budgets. *Business Insights: Global.* https://www.besa.org.uk/key-uk-education-statistics/

Brod, G. (2021). How can we make active learning work in K–12 education? Considering prerequisites for a successful construction of understanding. *Psychological Science in the Public Interest*, *22*(1), 1–7. https://doi.org/10.1177/1529100621997376

Bruner, J. S. (1960). *The process of education*. Harvard University Press.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, *31*, 21–32. https://psycnet.apa.org/record/1962-00777-001

Bruner, J. S. (1966). *Towards a theory of instruction*. Harvard University Press.

Bruner, J. S. (1975) From communication to language: A psychological perspective. *Cognition*, *3*, 811–132.

Burns, J., Krishnaratne, S., Pfadenhauer, L. M., Coenen, M., Geffert, K., Jung-Sievers, C., Klinger, C., Kratzer, S., Littlecott, H., Movsisyan, A., Rabe, J. E., Rehfuess, E., Sell, K., Strahwald, B., Stratil, J. M., Voss, S., Wabnitz, K., & Burns, J. (2020). Measures implemented in the school setting to contain the COVID-19 pandemic: A rapid scoping review. *Cochrane Library*, *2020*. https://doi.org/10.1002/14651858.CD013812

Cakiroglu, U., Erdogdu, F., & Gokoglu, S. (2018). Clickers in EFL classrooms: Evidence from two different uses. *Contemporary Educational Technology*, *9*(2), 171. https://doi.org/10.30935/cet.414820

Campos-Castillo, C. (2015). Revisiting the first-level digital divide in the United States: Gender and race/ethnicity patterns, 2007-2012. *Social Science Computer Review*, *33*(4), 423–439. https://doi.org/10.1177/0894439314547617

Cantú, E., & Farines, J. M. (2007). Applying educational models in technological education. *Education and Information Technologies*, *12*(3), 111–122. https://doi.org/10.1007/s10639-007-9038-4

Carter, S. P., Greenberg, K., & Walker, M. S. (2017). Should professors ban laptops? *Education Next*, *17*(4), 68. https://www.educationnext.org/should-professors-ban-laptops-classroom-computer-use-affects-student-learning-study/

Chang, I. H. (2012). The effect of principals' technological leadership on teachers' technological literacy and teaching effectiveness in Taiwanese elementary schools. *Educational Technology & Society*, *15*(2), 328–340.

Chaudhary, N., & Pillai, P. (2019). Bruner and beyond: A commentary. *Integrative Psychological & Behavioral Science*, *53*(4), 661–668. https://doi.org/10.1007/s12124-019-09486-3

Chen, C., Chang, W., & Lin, S. (2019). Spiral teaching sequence and concept maps for facilitating conceptual reasoning of acceleration. *Asia-Pacific Forum on Science Learning and Teaching*, *20*(1), 1–17.

Chmielewski, A. K. (2019). The global increase in the socioeconomic achievement gap, 1964 to 2015. *American Sociological Review*, *84*(3), 517–544. https://doi.org/10.1177/0003122419847165

Clark, R. M., & Mahboobin, A. (2018). Scaffolding to support problem-solving performance in a bioengineering lab-A case study. *IEEE Transactions on Education*, *61*(2), 109–118. https://doi.org/10.1109/TE.2017.2755601

Corn, J., Tagsold, J. T., & Argueta, R. (2012). Students with special needs and one-to-one computing: A teacher's perspective. *Journal of Research in Special Educational Needs*, *12*(4), 217–223. https://doi.org/10.1111/j.1471-3802.2012.01251.x

Cotti, C. D., Gordanier, J. M., & Ozturk, O. D. (2020). The relationship of opioid prescriptions and the educational performance of children. *Social Science & Medicine*, *265*, 113406-113406. https://doi.org/10.1016/j.socscimed.2020.113406

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications, Inc.

Crook, S. J., & Sharma, M. D. (2013). Bloom-ing heck! The activities of Australian science teachers and students two years into a one-to-one laptop program across 14 high schools. *International Journal of Innovation in Science and Mathematics Education*, *21*(1), 54-69. https://www-proquest-com.ezproxy.liberty.edu/docview/2248384604?pq-origsite=summon

Crook, S. J., Sharma, M. D., & Wilson, R. (2015). An evaluation of the impact of one-to-one laptops on student attainment in senior high school sciences. *International Journal of Science Education*, *37*(2), 272–293. https://doi:10.1080/09500693.2014.982229

Cuevas, J. A. (2016). An analysis of current evidence supporting two alternate learning models: Learning styles and dual coding. *Journal of Educational Sciences & Psychology, 6*(1). 1-13. https://digitalcommons.northgeorgia.edu/cgi/viewcontent.cgi?article=1077&context=ungauthors

Daniels, H. (2016). *Vygotsky and pedagogy*. Routledge. https://doi.org/10.4324/9781315617602

Daniels, H. (2017). *Introduction to Vygotsky*. Routledge. https://doi.org/10.4324/9781315647654

Dawson, K., Cavanaugh, C., & Ritzhaupt, A. D. (2008). Florida's EETT leveraging laptops initiative and its impact on teaching practices. *Journal of Research on Technology in Education*, *41*(2), 143–159. https://doi.org/10.1080/15391523.2008.10782526

DeMers, M. N. (2014). President's column: The ConnectED initiative and geography education. *Geography Teacher*, *11*(4), 174–175. https://doi.org/10.1080/19338341.2014.980640

Deng, Z. (2004). The fallacies of Jerome Bruner's hypothesis in "the process of education": A Deweyan perspective. *Journal of Educational Thought*, *38*(2), 151–170.

Dewey, J. (1929). *Experience and nature*. George Allen & Unwin.

Dewey, J. (1932). Universities: American, English, German. Abraham Flexner. *International Journal of Ethics, 42*(3), 331-332. https://doi.org/10.1086/intejethi.42.3.2989582

Dexter, S., & Richardson, J. W. (2020). What does technology integration research tell us about the leadership of technology? *Journal of Research on Technology in Education, 52*(1), 17-36. https://doi.org/10.1080/15391523.2019.1668316

Diamond, J. B. (2016). Where the rubber meets the road: Rethinking the connection between high-stakes testing policy and classroom instruction. *Sociology of Education*, *80*(4), 285–313. https://doi:10.1177/003804070708000401

Doron, E. & Spektor-Levy, O. (2019). Transformations in teachers' views in one-to-one classes: Longitudinal case studies. *Technology, Knowledge and Learning*, *24*(3), 437–460. https://doi:10.1007/s10758-017-9349-5

Elayyan, S. (2021). Education according to the fourth industrial revolution. *Journal of Educational Technology and Online Learning*, *4*(1), 23–30. https://doi.org/10.31681/jetol.737193

Elliott-Dorans, L. R. (2018). To ban or not to ban? The effect of permissive versus restrictive laptop policies on student outcomes and teaching evaluations. *Computers and Education*, *126*, 183–200. https://doi.org/10.1016/j.compedu.2018.07.008

Ellis, J., Fosdick, B. K., & Rasmussen, C. (2016). Women 1.5 times more likely to leave STEM pipeline after calculus compared to men: Lack of mathematical confidence a potential culprit. *PLoS One*, *11*(7), e0157447-e0157447. https://doi.org/10.1371/journal.pone.0157447

Engelhardt, B., Johnson, M., & Medes, M. (2021). Learning in time of COVID-19: Some preliminary findings. *International Review of Economics Education*, *37*, 100215. https://doi.org/10.1016/j.iree.2021.100215

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42(*3), 255–284. https://doi.org/10.1080/15391523.2010.10782551

Fani, T., & Ghaemi, F. (2011). Implications of Vygotsky's zone of proximal development (ZPD) in teacher education: ZPTD and self-scaffolding. *Procedia, Social and Behavioral Sciences*, *29*, 1549–1554. https://doi.org/10.1016/j.sbspro.2011.11.396

Faul, F., Erdfelder, E., Lang, A.-G. & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical Sciences. *Behavior Research Methods*, *39*, 175–191. https://doi.org/10.3758/BF03193146

Fernández, M., Wegerif, R., Mercer, N., & Rojas-Drummond, S. (2015). Re-conceptualizing “scaffolding” and the zone of proximal development in the context of symmetrical collaborative learning. *The Journal of Classroom Interaction*, *50*(1), 54–72.

Ferreira, M. J. (2012). Intelligent classrooms and smart software: Teaching and learning in today’s university. *Education and Information Technologies*, *17*(1), 3–25. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s10639-010-9134-8

Finn, S., & Inman, J. G. (2004). Digital unity and digital divide: Surveying alumni to study effects of a campus laptop initiative. *Journal of Research on Technology in Education*, *36*(3), 297–317. https://doi-org.ezproxy.liberty.edu/10.1080/15391523.2004.10782417

Fletcher, C. (2019). *Educational technology and the humanities: A history of control.* University of Minnesota Press. https://doi.org/10.5749/j.ctvg251hk.33

Flowers, B. S. (2018). Technology and humanity in the fourth industrial revolution. *Journal of International Affairs*, *72*(1), 179–181.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences – PNAS*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Furberg, A. (2016). Teacher support in computer-supported lab work: Bridging the gap between lab experiments and students’ conceptual understanding. *International Journal of*

Computing-Supported Collaborative Learning, *11*, 89–113. https://doi-org.ezproxy.liberty.edu/10.1007/s11412-016-9229-3

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: An introduction* (8th ed.). Pearson/Allyn & Bacon.

Gandolfi, E., Ferdig, R. E., & Kratcoski, A. (2021). A new educational normal an intersectionality-led exploration of education, learning technologies, and diversity during COVID-19. *Technology in Society*, *66*, 101637. https://doi.org/10.1016/j.techsoc.2021.101637

Garcia, M. (2017). 60 years ago: *The U.S. response to Sputnik*. National Aeronautics and Space Administration. https://www.nasa.gov/feature/60-years-ago-the-us-response-to-sputnik/

Gibbs, B. C. (2014). Reconfiguring Bruner: Compressing the spiral curriculum. *Phi Delta Kappan*, *95*(7), 41–44. https://doi.org/10.1177/003172171409500710

Giffi, C., Wellener, P., Dollar, B., Ashton Mangolian, H., Monck, L., & Moutray, C. (2018). *2018 Deloitte skills gap and future of work in manufacturing study*. Deloitte. https://www2.deloitte.com/content/dam/insights/us/articles/4736_2018-Deloitte-skills-gap-FoW-manufacturing/DI_2018-Deloitte-skills-gap-FoW-manufacturing-study.pdf

Glass, A. L., & Kang, M. (2019). Dividing attention in the classroom reduces exam performance. *Educational Psychology*, *39*(3), 395–408. https://doi.org/10.1080/01443410.2018.1489046

González-Estrada, E., & Cosmes, W. (2019). Shapiro-Wilk test for skew normal distributions based on data transformations. *Journal of Statistical Computation and Simulation*, *89*(17), 3258–3272. https://doi.org/10.1080/00949655.2019.1658763

Gopalan, M., Rosinger, K., & Ahn, J. B. (2020). Use of quasi-experimental research designs in education research: Growth, promise, and challenges. *Review of Research in Education*, *44*(1), 218–243. https://doi.org/10.3102/0091732X20903302

Gravemeijer, K. (2002). *Symbolizing, modeling and tool use in mathematics education.* Kluwer.

Grazzani, I., & Brockmeier, J. (2019). Language games and social cognition: Revisiting Bruner. *Integrative Psychological & Behavioral Science*, *53*(4), 602–610. https://doi.org/10.1007/s12124-019-09489-0

Greenfield, P. M. (2016). Jerome Bruner. *Nature*, *535*(7611), 232. http://dx.doi.org.ezproxy.liberty.edu/10.1038/535232a

Greenhow, C., Lewin, C., & Staudt Willet, K. B. (2020). The educational response to COVID-19 across two countries: A critical examination of initial digital pedagogy adoption. *Technology, Pedagogy and Education*, *30*(1), 1–19. https://doi.org/10.1080/1475939X.2020.1866654

Grundmeyer, T., & Peters, R. (2016). Learning from the learners: Preparing future teachers to leverage the benefits of laptop computers. *Computers in the Schools*, *3*3(4), 253–273. https://doi:10.1080/07380569.2017.1249757

Hall, C., Lundin, M., & Sibbmark, K. (2021). A laptop for every child? The impact of technology on human capital formation. *Labour Economics*, *69*. https://doi.org/10.1016/j.labeco.2020.101957

Happe, L., Buhnova, B., Koziolek, A., & Wagner, I. (2020). Effective measures to foster girls' interest in secondary computer science education: A literature review. *Education and Information Technologies*, *26*(3), 2811–2829. https://doi.org/10.1007/s10639-020-10379-x

Harper, B., & Milman, N. B. (2016). One-to-one technology in K-12 classrooms: A review of the literature from 2004 through 2014. *Journal of Research on Technology in Education*, *48*(2), 129–142. https://doi:10.1080/15391523.2016.1146564

Harris, J. L., Al-Bataineh, M. T., & Al-Bataineh, A. (2016). One-to-one technology and its effect on student academic achievement and motivation. *Contemporary Educational Technology*, *7*(4), 368. https://doi.org/10.30935/cedtech/6182

Heath, M. K. (2017). Teacher-initiated one-to-one technology initiatives: How teacher self-efficacy and beliefs help overcome barrier thresholds to implementation. *Computers in the Schools: One-to-One Technology Learning*, *34*(1–2), 88–106. https://doi:10.1080/07380569.2017.1305879

Hershkovitz, A., & Karni, O. (2018). Borders of change: A holistic exploration of teaching in one-to-one computing programs. *Computers and Education*, *125*, 429–443. https://doi.org/10.1016/j.compedu.2018.06.026

Higgins, K., & BuShell, S. (2018). The effects on the student-teacher relationship in a one-to-one technology classroom. *Education and Information Technologies*, *23*(3), 1069–1089. https://doi:10.1007/s10639-017-9648-4

Hockly, N. (2017). One-to-one computer initiatives. *ELT Journal*, *71*(1), 80–86. https://doi.org/10.1093/elt/ccw077

Holen, J. B., Hung, W., & Gourneau, B. (2017). Does one-to-one technology really work: An evaluation through the lens of activity theory. *Computers in the Schools: One-to-One Technology Learning*, *34*(1–2), 24–44. https://doi:10.1080/07380569.2017.1281698

Holzman, L. (2009). *Vygotsky at work and play.* Routledge. https://doi.org/10.4324/9780203889916

Horner, J. M. (2017). Rejecting dialogue for perspective: Vygotsky's zone of proximal development and John Calvin's divine pedagogy. *Religious Education*, *112*(2), 96–109. https://doi.org/10.1080/00344087.2016.1223492

Horvath, J. (2020). Where's the proof that computers help learning? *The Times Educational Supplement.*

Howard, S. K., Chan, A., & Caputi, P. (2015). More than beliefs: Subject areas and teachers' integration of laptops in secondary teaching. *British Journal of Educational Technology*, *46*(2), 360–369. https://doi.org/10.1111/bjet.12139

Huang, H., & Liaw, S. (2018). An analysis of learners' intentions toward virtual reality learning based on constructivist and technology acceptance approaches. *International Review of Research in Open and Distributed Learning*, *19*(1). https://doi:10.19173/irrodl.v19i1.2503

Huffman, D., Goldberg, F., & Michlin, M. (2003). Using computers to create constructivist learning environments: impact on pedagogy and achievement. *The Journal of Computers in Mathematics and Science Teaching*, *22*(2).

Hull, M., & Duch, K. (2019). One-to-one technology and student outcomes: Evidence from Mooresville's digital conversion initiative. *Educational Evaluation and Policy Analysis*, *41*(1), 79–97. https://doi:10.3102/0162373718799969

Hyer, J. M., & Waller, J. L. (2014). Comparison of five analytic techniques for two-group, pre-post repeated measures designs using SAS. National Library of Medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6022256/

Hyslop-Margison, E. J., & Sears, A. (2006). *Neo-liberalism, globalization and human capital learning: Reclaiming education for democratic citizenship*. Springer.

Hyslop-Margison, E. J., & Strobel, J. (2008). Constructivism and education: Misunderstandings and pedagogical implications. *The Teacher Educator*, *43*(1), 72–86. https://doi.org/10.1080/08878730701728945

Iivari, N., Sharma, S., & Ventä-Olkkonen, L. (2020). Digital transformation of everyday life: How COVID-19 pandemic transformed the basic education of the young generation and why information management research should care? *International Journal of Information Management*, *55*, 102183–102183. https://doi.org/10.1016/j.ijinfomgt.2020.102183

Islam, M. S., & Grönlund, Å. (2016). An international literature review of one-to-one computing in schools. *Journal of Educational Change*, *17*(2), 191–222. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s10833-016-9271-y

Istenič, A. (2021). Online learning under COVID-19: Re-examining the prominence of video-based and text-based feedback. *Educational Technology Research and Development*, *69*(1), 117–121.

Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning*, *24*(4), 271–283. https://doi.org/10.1111/j.1365-2729.2007.00259.x

Jaime, A., Blanco, J. M., Domínguez, C., Sánchez, A., Heras, J., & Usandizaga, I. (2016). Spiral and project-based learning with peer assessment in a computer science project management course. *Journal of Science Education and Technology*, *25*(3), 439–449. https://doi.org/10.1007/s10956-016-9604-x

Jayman, M., & Ohl, M. (2021). *Supporting new digital natives: Children's mental health and wellbeing in a hi-tech age* (1st ed.). Policy Press.

Johnson, C. C., & Walton, J. B. (2015). Examining the leaky STEM talent pipeline: Need for further research. *School Science and Mathematics*, *115*(8), 379–380. https://doi:10.1111/ssm.12148

Johnson, L., Adams, S., Estrada, V., & Freeman, A. (2014). *NMC horizon report: 2014 K–12 edition*. The New Media Consortium.

Kang, H., Calabrese Barton, A., Tan, E., Simpkins, S., Rhee, H., & Turner, C. (2019). How do middle school females of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers. *Science Education*, *103*(2), 418–439. https://doi.org/10.1002/sce.21492

Keane, T., Boden, M., Chalmers, C., & Williams, M. (2020). Effective principal leadership influencing technology innovation in the classroom. *Education and Information Technologies*, *25*(6), 5321–5338. https://doi.org/10.1007/s10639-020-10217-0

Kim, N. J., Belland, B. R., Lefler, M., Andreasen, L., Walker, A., & Axelrod, D. (2020). Computer-based scaffolding targeting individual versus groups in problem-centered instruction for STEM education: Meta-analysis. *Educational Psychology Review*, *32*(2), 415–461. https://doi.org/10.1007/s10648-019-09502-3

Kim, Y., & Steiner, P. (2016). Quasi-experimental designs for causal inference. *Educational Psychologist*, *51*(3–4), 395–405. https://doi.org/10.1080/00461520.2016.1207177

King, N. S., & Pringle, R. M. (2019). Black girls speak STEM: Counterstories of informal and formal learning experiences. *Journal of Research in Science Teaching*, *56*(5), 539–569. https://doi.org/10.1002/tea.21513

Kirley, E. A. (2015). Are we ethically bound to use student engagement technologies for teaching law? *Law Teacher*, *49*(2), 219–241. https://doi.org/10.1080/03069400.2015.1035560

Kocdar, S., Bozkurt, A., & Goru Dogan, T. (2021). Engineering through distance education in the time of the fourth industrial revolution: Reflections from three decades of peer reviewed studies. *Computer Applications in Engineering Education*, *29*(4), 931–949. https://doi.org/10.1002/cae.22367

Kozma, R. (2003). The material features of multiple representations and their cognitive and social affordances for science understanding. *Learning and Instruction*, *13*, 205–226. https://doi.org/10.1016/S0959-4752(02)00021-X

Kulik, C. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior*, *7*(1), 75–94. https://doi.org/10.1016/0747-5632(91)90030-5

Kwon, K., Ottenbreit-Leftwich, A. T., Sari, A. R., Khlaif, Z., Zhu, M., Nadir, H., & Gok, F. (2019). Teachers' self-efficacy matters: Exploring the integration of mobile computing device in middle schools. *Techtrends*, *63*(6), 682–692. https://doi.org/10.1007/s11528-019-00402-5

Larkin, K. (2014). You use, I use, we use: Questioning the orthodoxy of one-to-one computing in primary schools. *Journal of Research on Technology in Education*, *44*(2), 101–120. https://doi.org/10.1080/15391523.2011.10782581

Larkin, K., & Finger, G. (2011). Informing one-to-one computing in primary schools: Student use of netbooks. *Australasian Journal of Educational Technology*, *27*(3), 514–530. https://doi.org/10.14742/ajet.958

Lee, D., Huh, Y., Lin, C., & Reigeluth, C. M. (2018). Technology functions for personalized learning in learner-centered schools. *Educational Technology Research and Development*, *66(*5), 1269–1302. https://doi.org/10.1007/s11423-018-9615-9

Levinson, M. (2010). Keeping the peace: Nueva School learned a tough lesson when rampant instant messaging led to an uproar over what technology was appropriate for their middle school one-to-one initiative. *Learning and Leading with Technology: The ISTE Journal of Educational Technology Practice and Policy*, *37*(5), 16.

Lewis, K. (2020). Technology in the workplace: Redefining skills for the 21st-century. The *Midwest Quarterly*, *61*(3), 348–355.

Lieberman, M. (2020). Coronavirus prompting e-learning strategies. *Education Week*, *39*(24), 11.

Linn, M., & Eylon, B.-S. (2011). *Science learning and instruction. taking advantage of technology to promote knowledge integration*. Routledge.

Liu, F., Ritzhaupt, A. D., Dawson, K., & Barron, A. E. (2017). Explaining technology integration in K–12 classrooms: A multilevel path analysis model. *Educational Technology Research and Development*, *65(*4), 795–813. https://doi.org/10.1007/s11423-016-9487-9

Liu, S. C., Brown, S. E. V., & Sabat, I. E. (2019). Patching the "leaky pipeline": Interventions for women of color faculty in STEM academia. *Archives of Scientific Psychology*, *7*(1), 32–39. https://doi.org/10.1037/arc0000062

Lowther, D. L., Inan, F. A., Ross, S. M., & Strahl, J. D. (2012). Do one-to-one initiatives bridge the way to 21st century knowledge and skills? *Journal of Educational Computing Research*, *46(*1), 1–30.

MacGillis, A. (2020). School's out. *The New Yorker*, *96*(30).

Martella, R. C., Nelson, J. R., Morgan, R. L., & Marchand-Martella, N. E. (2013). *Understanding and interpreting educational research*. The Guilford Press.

Martino, L. M. (2021). Postsecondary teacher quality and student achievement in Florida's career certificate programs using a causal-comparative study. *Career and Technical Education Research*, *46*(1), 16–33. https://doi.org/10.5328/cter46.1.16

Mattar, J. (2018). Constructivism and connectivism in education technology: Active, situated, authentic, experiential, and anchored learning. *Revista Iberoamericana De Educación a Distancia*, *21*(2), 201–217. https://doi.org/10.5944/ried.21.2.20055

Maxwell, N. G. (2007). From Facebook to Folsom prison blues: How banning laptops in the classroom made me a better law school teacher. *Richmond Journal of Law*, *14*(2). https://scholarship.richmond.edu/jolt/vol14/iss2/2/

McLay, M. (1998). Anytime, anywhere learning. *Teach*, *9*.

McNeil, N. M., & Uttal, D. H. (2009). Rethinking the use of concrete materials in learning: Perspectives from development and education. *Child Development Perspectives*, *3*(3), 137–139. https://doi.org/10.1111/j.1750-8606.2009.00093.x

Mcwilliam, E., & Dawson, S. (2008). Teaching for creativity: Towards sustainable and replicable pedagogical practice. *Higher Education*, *56*(6), 633–643. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s10734-008-9115-7

Michigan State University. (n.d.). *Academic programs catalog: Undergraduate education*. https://reg.msu.edu/AcademicPrograms/Print.aspx?Section=135

Middleton, K. V. (2020). The longer-term impact of COVID-19 on K–12 student learning and assessment. *Educational Measurement, Issues and Practice*, *39*(3), 41–44. https://doi.org/10.1111/emip.12368

Moll, L.C. (2014). *L. S. Vygotsky and education*. Routledge.

Molnar, A. S. (1997). Computers in education: A brief history. *T.H.E. Journal: Technological Horizons in Education*, *24*(11), 63.

Morse, J. M. (2015). Critical analysis of strategies for determining rigor in qualitative inquiry. *Qualitative Health Research*, *25*(9), 1212–1222. https://doi.org/10.1177/1049732315588501

Mueller, P. A., & Oppenheimer, D. M. (2016). Technology and note-taking in the classroom, boardroom, hospital room, and courtroom. *Trends in Neuroscience and Education*, *5*(3), 139–145. https://doi.org/10.1016/j.tine.2016.06.002

Nagel, M., & Lindsey, B. (2018). The use of classroom clickers to support improved self-assessment in introductory chemistry. *Journal of College Science Teaching*, *47*(5), 72–79.

National Commission on Excellence in Education (NCEE). (1983). *A nation at risk*. U.S. Department of Education.

Newman, S., & Latifi, A. (2021). Vygotsky, education, and teacher education. *Journal of Education for Teaching: JET*, *47*(1), 4–17. https://doi.org/10.1080/02607476.2020.1831375

Nielsen, W., Miller, K. A., & Hoban, G. (2015). Science teachers' response to the digital education revolution. *Journal of Science Education and Technology*, *24*(4), 417–431. https://dx.doi.org.ezproxy.liberty.edu/10.1007/s10956-014-9527-3

Oliver, K. M., & Corn, J. O. (2008). Student-reported differences in technology use and skills after the implementation of one-to-one computing. *Educational Media International*, *45*(3), 215–229. https://doi.org/10.1080/09523980802284333

Olson, S., & Riordan, D (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Report to the President*. Executive Office of the President. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/fact_sheet_final.pdf

Osborne, J. H., & Morgan, H. (2016). Alleviating the digital divide in the United States. *Childhood Education*, *92*(3), 254–256.

Osimani, F., Stecanella, B., Capdehourat, G., Etcheverry, L., & Grampín, E. (2019). Managing devices of a one-to-one computing educational program using an IoT infrastructure. *Sensors*, *19*(1). http://dx.doi.org.ezproxy.liberty.edu/10.3390/s19010070

Outlay, C., Platt, A., & Conroy, K. (2017). Getting IT together: A longitudinal look at linking girls' interest in IT careers to lessons taught in middle school camps. *ACM Transactions on Computing Education*, *17*(4), 1–17. https://doi.org/10.1145/3068838

Parkhouse, H., Gorlewski, J., Senechal, J., & Lu, C. Y. (2021). Ripple effects: How teacher action research on culturally relevant education can promote systemic change. *Action in Teacher Education*, *35*(4), 1–19. https://doi.org/10.1080/01626620.2021.1896395

Parks, A. N., & Tortorelli, L. (2020). Impact of a district-wide one-to-one technology initiative on kindergartners' engagement and learning outcomes. *Journal of Research in Childhood Education*, *34*, 1–14. https://doi.org/10.1080/02568543.2020.1809578

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008;2009;). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest, 9*(3), 105-119. https://doi.org/10.1111/j.1539-6053.2009.01038.x

Patterson, R., & Patterson, R. (2017). Computers and productivity: Evidence from laptop use in the college classroom. *Economics of Education Review*, *57*, 66–79. https://doi-org.ezproxy.liberty.edu/10.1016/j.econedurev.2017.02.004

Peel, L. (2015). Obama announces ConnectED initiatives. *Library Journal*, *140*(10), 16.

Petrilli, M. J. (2017). A common core curriculum quandary. *Education Next*, *17*(3).

Piaget, J. (1952). *Origins of intelligence in children*. International Universities Press.

Pinkard, N., Erete, S., Martin, C. K., & McKinney de Royston, M. (2017). Digital youth divas: Exploring narrative-driven curriculum to spark middle school girls' interest in computational activities. *The Journal of the Learning Sciences*, *26*(3), 477–516. https://doi.org/10.1080/10508406.2017.1307199

Porter, A., McMaken, J., Hwang, J., & Yang, R. (2011). Common core standards: The new U.S. intended curriculum. *Educational Researcher*, *40*(3), 103–116. https://doi.org/10.3102/0013189X11405038

Puhan, M. A., Akl, E. A., Bryant, D., Xie, F., Apolone, G., & ter Riet, G. (2012). Discussing study limitations in reports of biomedical studies-the need for more transparency. *Health and Quality of Life Outcomes*, *10(*1), 23. https://doi.org/10.1186/1477-7525-10-23

Reisdorf, B. C., Triwibowo, W., & Yankelevich, A. (2020). Laptop or bust: How lack of technology affects student achievement. *The American Behavioral Scientist*, *64*(7), 927–949. https://doi.org/10.1177/0002764220919145

Rovai, A. P., Baker, J. D., & Ponton, M. K. (2014). *Social science research design and statistics: A practitioner's guide to research methods and IBM SPSS analysis* (2nd ed.). Watertree Press.

Ruggeri, A., Markant, D. B., Gureckis, T. M., Bretzke, M., Xu, F. (2019). Memory enhancements from active control of learning emerge across development. *Cognition*, *186*, 82–94. https://doi-org.ezproxy.liberty.edu/10.1016/j.cognition.2019.01.010

Ruipérez-Valiente, J. A., & Kim, Y. J. (2020). Effects of solo vs. collaborative play in a digital learning game on geometry: Results from a K12 experiment. *Computers and Education*, *159*. https://doi.org/10.1016/j.compedu.2020.104008

Sack, J. L. (2003). Maine. *Education Week*, *22*(35), 72.

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

Salkind, N. J. (2010). *Encyclopedia of research design: Volume 1.* SAGE Publications, Inc.

Santo, R., DeLyser, L. A., & Ahn, J. (2020). Negotiating equity priorities within systems change: A case study of a district-level initiative to implement K12 computer science education. *Computing in Science & Engineering*, *22*(5), 7–19. https://doi.org/10.1109/MCSE.2020.3008434

Saunders, M., Barr, B., McHale, P., & Hamelmann, C. (2017). *Key policies for addressing the social determinants of health and health inequities*. Health Evidence Network.

Sarama, J., & Clements, D. H. (2009). “Concrete” computer manipulatives in mathematics education. *Child Development Perspectives*, *3*, 145–150. https://doi.org/10.1111/j.1750-8606.2009.00095.x

Schiferl, J. (2020, March). SC schools approved to suspend standardized testing this spring. *The Post and Courier*. https://www.postandcourier.com/health/covid19/sc-schools-approved-to-suspend-standardized-testing-this-spring/article_98cf0fd2-6d43-11ea-bc40-374c92d55ea8.html

Schwartz, D. L., & Bransford, J. D. (1998). A time for telling. *Cognition and Instruction*, *16*(4), 475–522. https://doi.org/10.1207/s1532690xci1604_4

Semas, J. H. (2001). Mega instillation: With 23,000 new laptops in hand, the Henrico, Virginia, district has big plans for going paperless. *Curriculum Administrator*, *37*(7), 18.

Shapley, K. S., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2011). Effects of technology immersion on middle school students' learning opportunities and achievement. *Journal of Educational Research*, *104*(5), 299–315.

Shvarts, A., & Bakker, A. (2019). The early history of the scaffolding metaphor: Bernstein, Luria, Vygotsky, and before. *Mind, Culture and Activity*, *26*(1), 4–23. https://doi.org/10.1080/10749039.2019.1574306

Siegel, H. (2004). The bearing of philosophy of science-on-science education, and vice versa: The case of constructivism. *Studies in History and Philosophy of Science*, *35*, 185–198. https://doi.org/10.1016/j.shpsa.2003.12.001

Simon, M., Marttinen, R., & Phillips, S. (2020). Marginalized girls' gendered experiences within a constructivist afterschool program (REACH). *Sport, Education and Society*, *26*(6), 1–13. https://doi.org/10.1080/13573322.2020.1764926

Smith, W. C. (2017). National testing policies and educator-based testing for accountability: The role of selection in student achievement. *OECD Economic Studies*, *2016*(1), 131–149.

Smorti, A. (2019). Jerome Seymour Bruner: An anticipator scientist for an anticipation theory. *Integrative Psychological & Behavioral Science*, *53*(4), 573–582. https://doi.org/10.1007/s12124-019-09480-9

Snyder, J. J., Sloane, J. D., Dunk, R. D. P., & Wiles, J. R. (2016). Peer-led team learning helps minority students succeed. *PLoS Biology*, *14*(3), e1002398. https://doi:10.1371/journal.pbio.1002398

South Carolina Department of Education. (2020a). *South Carolina Palmetto Assessment of State Standards (SCPASS) Science and Social Studies*. https://ed.sc.gov/tests/middle/scpass/

South Carolina Department of Education. (2020b). *South Carolina Palmetto Assessment of State Standards Test Administration Manual*. https://ed.sc.gov/tests/tests-files/sc-ready-files/sc-ready-and-scpass-spring-2020-test-administration-manual-for-online-testing/

Stager, G. S. (2016). Seymour Papert (1928–2016). *Nature*, *537*(7620), 308–308. https://doi.org/10.1038/537308a

Standardized Testing Overburdens Pupils (STOP) Act, S.C. Stat.§ 50.18.325–50.18.325. (2019). https://www.scstatehouse.gov/sess123_2019-2020/bills/233.htm

Stapleton, L., & Stefaniak, J. (2019). Cognitive constructivism: Revisiting Jerome Bruner's influence on instructional design practices. *TechTrends*, *63*(1), 4–5. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s11528-018-0356-8

Sung, Y., Change, K., & Liu, T. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008.

Swallow, M. (2015). The year-two decline: Exploring the incremental experiences of a one-to-one technology initiative. *Journal of Research on Technology in Education*, *47*(2), 122–137. https://doi-orgezproxy.liberty.edu/10.1080/15391523.2015.999641

Szente, J. (2020). Live virtual sessions with toddlers and preschoolers amid COVID-19: Implications for early childhood teacher education. *Journal of Technology and Teacher Education*, *28*(2), 373–380.

Tatnall, A., & Davey, B. (2014). *Reflections on the history of computers in education: Early use of computers and teaching about computing in schools*. Springer. https://doi.org/10.1007/978-3-642-55119-2

Tedre, M., Simon, & Malmi, L. (2018). Changing aims of computing education: A historical survey. *Computer Science Education*, *28*(2), 158–186. https://doi:10.1080/08993408.2018.1486624

Topper, A., & Lancaster, S. (2013). Common challenges and experiences of school districts that are implementing one-to-one computing initiatives. *Computers in the Schools*, *30*(4), 346–358. https://doi.org/10.1080/07380569.2013.844640

Upham, P., Carney, S., & Klapper, R. (2014). Scaffolding, software and scenarios: Applying Bruner's learning theory to energy scenario development with the public. *Technological Forecasting & Social Change*, *81*, 131–142. https://doi.org/10.1016/j.techfore.2013.05.001

Van Moere, A., & Hanlon, S. (2020). A Bayesian approach to improving measurement precision over multiple test occasions. *Language Testing*, *37*(4), 482–502. https://doi.org/10.1177/0265532220934203

Vincent-Lancrin, S., Urgel, J., Kar, S., & Jacotin, G. (2019). *Measuring innovation in education 2019: What has changed in the classroom?* OECD Publishing. https://doi.org/10.1787/9789264311671-en

Volkov, A., & Freiman, V. (2019). *Computations and computing devices in mathematics education before the advent of electronic calculators*. Springer.

Vygotsky, L. S. (1962). *Thought and language*. MIT Press.

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

Vygotsky, L. S. (2004). Imagination and creativity in childhood. *Journal of Russian and East European Psychology*, *42(*1), 7–97. https://doi.org/10.1080/10610405.2004.11059210

Walshaw, M. (2017). Understanding mathematical development through Vygotsky. *Research in Mathematics Education*, *19*(3), 293–309. https://doi.org/10.1080/14794802.2017.1379728

Warner, R. M. (2013). *Applied statistics: From bivariate through multivariate techniques* (2nd ed.). SAGE Publications, Inc.

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

Witteveen, D., & Attewell, P. (2020). The STEM grading penalty: An alternative to the "leaky pipeline" hypothesis. *Science Education*, *104*(4), 714–735. https://doi:10.1002/sce.21580

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, *17*(2), 89–100. https://doi-org.ezproxy.liberty.edu/10.1111/j.1469-7610.1976.tb00381.x

Wu, J., & Cheng, T. (2019). Who is better adapted in learning online within the personal learning environment? Relating gender differences in cognitive attention networks to digital distraction. *Computers and Education*, *128*, 312–329. https://doi.org/10.1016/j.compedu.2018.08.016

Xie, J., A., & Rice, M. F. (2021). Instructional designers' roles in emergency remote teaching during COVID-19. *Distance Education*, *42*(1), 70–87. https://doi.org/10.1080/01587919.2020.1869526

Xu, S. (2019). Revisiting Bruner's legacy from the perspective of historical materialism. *Integrative Psychological & Behavioral Science*, *53*(4), 590–601. https://doi.org/10.1007/s12124-019-09490-7

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: Pedagogical approaches to embedding 21st-century problem solving in K-12 classrooms. *Techtrends*, *60*(6), 565–568. https://doi.org/10.1007/s11528-016-0087-7

Yasnitsky, A. (2018). *Vygotsky: An intellectual biography*. Routledge. https://doi.org/10.4324/9781315751504

Yelland, N., & Masters, J. (2007). Rethinking scaffolding in the information age. *Computers and Education*, *48(*3), 362–382. https://doi:10.1016/j.compedu.2005.01.010

Zheng, B., Warschauer, M., Lin, C., & Chang, C. (2016). Learning in one-to-one laptop environments: A meta-analysis and research synthesis. *Review of Educational Research*, *86*(4), 1052–1084. https://doi:10.3102/0034654316628645

Zheng, L., Zhen, Y., Niu, J., & Zhong, L. (2022). An exploratory study on fade-in versus fade-out scaffolding for novice programmers in online collaborative programming settings. *Journal of Computing in Higher Education*, 1–28. https://doi.org/10.1007/s12528-021-09307-w

Zucker, A. A., & Hug, S. T. (2008). Teaching and learning physics in a one-to-one laptop school. *Journal of Science Education and Technology*, *17*(6), 586–594. https://doi.org/10.1007/s10956-008-9125-3

APPENDIX A: Institutional Review Board Permission

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

February 1, 2022

Windy Hammond
Jeffrey Savage

Re: IRB Application - IRB-FY21-22-579 THE DIFFERENCE BETWEEN SEVENTH GRADE FEMALE AND MALE TEST SCORES BASED ON ONE-TO-ONE TECHNOLOGY ACCESS: A CAUSAL-COMPARATIVE STUDY

Dear Windy Hammond and Jeffrey Savage,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your project with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study is not considered human subjects research for the following reason:

It will not involve the collection of identifiable, private information from or about living individuals (45 CFR 46.102).

Please note that this decision only applies to your current application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

Also, although you are welcome to use our recruitment and consent templates, you are not required to do so. If you choose to use our documents, please replace the word *research* with the word *project* throughout both documents.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

[redacted]
Administrative Chair of Institutional Research
Research Ethics Office

APPENDIX B: Request to School Districts for Approval to Access Archived Data

February 1, 2022
[redacted] Public Schools
Chief Technology and Innovation Officer

Dear [redacted]

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a Ph.D. in Curriculum and Instruction. The title of my research project is The Difference between Seventh-Grade Female and Male Test Scores Based on One-to-One Technology Access: A Causal-Comparative Study and the purpose of my research is to discover any relationships between test scores and the use of one-to-one technology in the form of Chromebooks or laptops.

I would like to inquire whether your district provided one-to-one technology for every student in the seventh grade during the 2016-2017 school year. Thank you for considering my request. If you choose to grant permission, please provide a signed statement indicating your approval and use of one-to-one technology or respond by email to wshammond@liberty.edu. A permission letter document is attached for your convenience.

Sincerely,

Windy S. Hammond, Ed.S.

APPENDIX C: Example Permission Form

February 3, 2022

Windy Hammond
[redacted]

[redacted]

Dear Windy Hammond:

After careful review of your research proposal entitled The Difference between Seventh-Grade Female and Male Test Scores Based on One-to-One Technology Access: A Causal-Comparative Study, I am providing the information you need to complete your research.

Check the following boxes as applicable:

☐ The use of one-to-one technology was provided for seventh-grade students in the form of laptops/Chromebooks during the 2016-2017 school year.

☐ The use of one-to-one technology was not provided for seventh-grade students in the form of laptops/Chromebooks during the 2016-2017 school year.

☐ I/We are requesting a copy of the results upon study completion and/or publication.

Sincerely,

APPENDIX D: Email Approval Letter A

[redacted]

February 4, 2022

Windy Hammond
[redacted]

Dear Windy Hammond:

After careful review of your research proposal entitled The Difference between Seventh-Grade Female and Male Test Scores Based on One-to-One Technology Access: A Causal-Comparative Study, I am providing the information you need to complete your research.

Check the following boxes as applicable:

✓ The use of one-to-one technology was provided for seventh-grade students in the form of laptops/Chromebooks during the 2016-2017 school year.

☐ The use of one-to-one technology was not provided for seventh-grade students in the form of laptops/Chromebooks during the 2016-2017 school year.

☐ I/We are requesting a copy of the results upon study completion and/or publication.

Sincerely,
[redacted]

APPENDIX E: Email Approval Letter B

February 3, 2022

[redacted], Ed.D. Director of Assessment, Data and Research

____

To Whom it May Concern,

This letter gives approval for Windy Hammond to conduct a research study titled “The Difference between Seventh-Grade Female and Male Test Scores Based on One-to-One Technology Access: A Causal-Comparative Study” using district data. Your research request has been reviewed and you are given permission to move forward. Below are the answers to your inquiry:

☐ The use of one-to-one technology was provided for seventh-grade students in the form of laptops/Chromebooks during the 2016-2017 school year.

X The use of one-to-one technology was not provided for seventh-grade students in the form of laptops/Chromebooks during the 2016-2017 school year.

☐ I/We are requesting a copy of the results upon study completion and/or publication.

We wish you the best in your research!

Respectfully,

[redacted]

APPENDIX F: SCPASS Cutoff Scores

SCPASS Science Scores

Does Not Meet	Approaches	Meets	Exceeds
1670–1734	1735–1749	1750–1767	1768–1830

SCPASS Social Studies Scores

Not Met	Met	Exemplary
300–599	600–644	645–900