2023

Comparison of Achievement Differences Based on Years of Participation in a One-to-One Laptop Program

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by
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An Applied Dissertation Submitted to the
Abraham S. Fischler College of Education
and School of Criminal Justice in Partial
Fulfillment of the Requirements for the
Degree of Doctor of Education

Nova Southeastern University
2023

Approval Page

This applied dissertation was submitted by Anne Elizabeth Petersen-Carnell under the direction of the persons listed below. It was submitted to the Abraham S. Fischler College of Education and School of Criminal Justice and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova Southeastern University.

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Statement of Original Work

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Abstract

Comparison of Achievement Differences Based on Years of Participation in a One-to-One Laptop Program. Anne Elizabeth Petersen-Carnell, 2023: Applied Dissertation, Nova Southeastern University, Abraham S. Fischler College of Education and School of Criminal Justice. Keywords: student achievement, benchmarking, digital divide, socioeconomic status

The purpose of this quantitative, causal-comparative study was to determine the extent to which a statistically significant difference existed in eighth-grade English-language arts (ELA) and mathematics achievement between groups of students of low socioeconomic status (SES) who participated in a Washington school district's one-to-one laptop program for 1 year versus 3 years. Siemens' (2005) connectivism theory served as the theoretical framework for the study. The problem addressed by the study involved the digital divide. According to van Dijk (2006), the digital divide is defined as unequal access to computers and the Internet based on economic status. The research questions asked if and to what extent a statistically significant difference existed between 2016 eighth-grade ELA and mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA and mathematics achievement for students of low SES who participated in the program for 3 years in a mid-sized, suburban school district in the state of Washington.

The 2016 and 2018 ELA and mathematics summative archival data from the Smarter Balanced were used to measure achievement of eighth-grade students of low SES who participated in 1 year compared to 3 years of a one-to-one laptop program. The total sample used for the analysis of eighth-grade ELA summative achievement scale scores for students of low SES was as follows: Group 1 (2016) included 338, and Group 2 (2018) included 328. The total sample used for the analysis of eighth-grade mathematics summative achievement scale scores for students of low SES was as follows: Group 3 (2016) included 341, and Group 4 (2018) included 326. An independent-samples *t* test was used to test the hypotheses.

Findings of the study were that a statistically significant difference existed between groups. For both Research Questions 1 and 2, the independent-samples *t* test generated a *p* value that was statistically significant at .001, and the Levene's test determined it was statistically supported. For both Research Questions 1 and 2, the null hypothesis was rejected and the alternate hypothesis was accepted. The findings of this study provide insight into the potential impacts of the implementation of one-to-one computer programs and may help to inform technology spending decisions in the public school setting.

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Chapter 1: Introduction

Statement of the Problem

A digital divide exists in education. According to Shami-Iyabo (2020), the problem space known as the digital divide is prevalent in education and may negatively affect the achievement of students of low socioeconomic status (SES). Historically, student achievement is predicted by their family's socioeconomic status, as well as by the SES of their school (Neuman et al., 2018). The digital divide is defined as unequal access to computers and the Internet based on economic status (van Dijk, 2006). For this reason, participants for the study were low SES eighth-grade students. The setting for the study involved eighth-grade English-language arts (ELA) and mathematics classrooms in a Washington school district. Low SES status was determined based on students' free and reduced lunch status. Putri et al. (2020) highlighted the link between low-income status and access to Internet connected technology and noted this disparity as the digital divide, depicting a state of society wherein inequality exists due to unequal distribution or the lack of equitable access to technology. Digital divide impacts may affect individuals of low SES both at home and at school.

Existing trends in education may be antecedents to the development of a digital divide within a school setting. Bring your own device (BYOD) programs are an example of an antecedent to the development of a digital divide in a school setting (Chou et al., 2017). BYOD programs may exacerbate visible inequities between the haves and the have-nots as some students are able to bring computers while others are not, or the devices brought are sub-par (Chou et al., 2017; McLean, 2016). Another antecedent to the development of the digital divide in schools involves technology tracking programs (Lanford et al., 2019). Technology tracking programs in schools provide devices only for students in college preparatory classes, furthering visible inequities of the digital divide (Lanford et al., 2019). Additional factors contributing to the digital divide for students of low SES are digital bind schools (Robinson et al., 2018). These schools require students to use computers and/or Internet for schoolwork, but do not provide either (Robinson et al., 2018). A digital bind school environment deepens the digital divide for students without computer access at home (Anderson & Perrin, 2018). Technology integration programs like BYOD, technology tracking, and digital bind programs can be antecedents that contribute to the digital divide. These programs do not promote equitable access to learning in the same way one-to-one programs do, where all students are provided with a computer and Internet access by the school. This study addressed the problem space of the digital divide by examining the impact of a one-to-one computer program on student achievement, specifically in the areas of ELA and mathematics.

The Research Problem

The research problem was that it was not known to what extent differences existed in eighth-grade ELA and mathematics summative assessment achievement outcomes for students of low SES based on years of participation in a Washington school district's one-to-one laptop program. This research problem aligns with the research gap identified by Weber and Becker (2019), stating the need for future long-term research to investigate whether school-related information and communications technology (ICT) use impacts student achievement. This study analyzed differences in student achievement based on years of participation in a one-to-one laptop program. The research problem was determined based on what remains to be understood as defined in the problem space of the digital divide and review of the literature. A review of the literature revealed the research problem of the digital divide that exists in education today despite large investments in technology by school districts.

Despite widespread computer availability, not all teachers and students have ubiquitous access. More dollars are spent each year by the United States on K-12 public education than by any other country across the globe. However, the availability and expectations for educational use of computers are ever expanding while equitable access is not (Chou et al., 2017). Equity in access to technology has been described as those who have access and those who do not have access. Those without may include students, parents, and other adults in the community on the wrong side of the digital divide.

Digital divide is a term used to describe unequal access to computers and other technologies. Individuals of low SES without consistent access to computers and the Internet are especially impacted by the digital divide. Digital divide is the disparity, which involves the economic and social inequality of equitable access and use of Internet connected computers and technologies. Low-income students are more likely to experience the effects of the digital divide (Talaee & Noroozi, 2019). At home, students of the digital divide experience more challenges related to unreliable access to a computer or the Internet than non-low-income peers (Anderson & Perrin, 2018). Anderson and Perrin (2018) shared that those digital hurdles make completing homework impossible for some, and extremely difficult for others. Therefore, the digital divide is a problem in the field of education.

Scope of the Problem

The scope of the problem of the digital divide impacting school-aged students is vast. Broad connections exist between economic and social exclusion as the result of digital divide (Bach et al., 2018). COVID-19 has compounded educational disparities thus broadening existing achievement gaps between students of high and low SES (Reza, 2020). Without access to an ICT, minority students and students of color frequently experience barriers to participation in online learning (Reza, 2020). School districts are working to address technology related barriers; however, many students continue to be impacted (Reza, 2020). The importance of addressing the problem of the digital divide in this study will provide information to school districts interested in narrowing and eradicating the digital divide within schools. Results from this study may inform school districts on the impacts of one-to-one laptop programs on student achievement for students of low SES impacted by the digital divide. The digital divide is a societal issue (van Deursen & van Dijk, 2019). Therefore, the information from the study may have societal level benefits.

What Needs to Be Understood

The problem statement was developed based on what remains to be understood as defined in the problem space of the digital divide, and review of the literature. This study will provide information to school districts interested in examining their practice of achieving equity in technology integration to decrease the digital divide. The need for future research and what is yet to be understood about the impacts of one-to-one programs on summative test data is evident in the literature (Agasisti et al., 2020; Hazlett et al., 2019; Vu et al., 2019).

Future research is needed to examine whether and how digital technology can foster achievement, and whether it can nurture deep learning (Rizk & Davies, 2021). In addition, future research is needed regarding student achievement by students in poverty (Bass, 2021) in one-to-one programs (Bixler, 2019). Weber and Becker (2019) called for the need for long-term studies to investigate whether use of the Internet connected devices for school-related activities is connected with higher educational achievement and further success. This study addressed these needs by examining student achievement as the study's dependent variable. Additionally, this study utilized the achievement scores of students of low SES for the data analysis. Finally, this study addressed the issue of time by utilizing years of participation in a one-to-one laptop program as the independent variable.

Increased spending in educational settings may increase equity across socioeconomic lines, and reduce the digital divide (Mann, 2019). Addressing the problem of the digital divide is important because of its current scope in education as categorical inequalities in society continue to persist. Insufficient ICT access for students from lower SES in comparison to higher SES peers, contributes significantly to inequality in ICT use (Mann, 2019). It is imperative for school leaders to critically assess racial and economic parameters driving practice and norms pertaining to digital pedagogy (Mann, 2019). Therefore, the research that needs to be better understood is impacts of one-to-one programs based on summative test data for students of low SES. The current study provided research information for this topic.

Background and Justification

There is conflicting research investigating the topic of achievement and one-to-one laptop programs. The need for future research to measure the academic impacts of one-to-one programs on students' achievement on summative tests has been documented in the research. A summary of results from prior empirical research reveals that frequency of educational computer use is not consistently related to increased school performance (Weber & Becker, 2019). However, research exists supporting a positive relationship between educational computer use and student achievement (Robinson et al., 2018). Researchers have noted the need for research on the association between students in one-to-one environments and potential impacts on academic performance. One-to-one environments include students of diverse backgrounds, SES, and academic abilities.

Karlsson (2020) provided information that helps establish the research gap for this study. The author identified the need for future studies focusing on the causal effect of computers on student achievement when computers are implemented on a larger scale. In addition, the author recommended examining the role of computers in subjects other than mathematics and science. Research by Vu et al. (2019) contributed information to substantiate a gap for this study. The authors noted a need for future research focused on one-to-one initiatives and formal formative and summative evaluations of student learning. Rizk and Davies (2021) also identified a gap in the research that was addressed by this study. The authors provided information to help support the gap presented in this study. They called for future research to address whether digital technology in schools can foster achievement. Bass (2021) contributed to research by bearing out the gap that was examined in this study and opined that future research is needed regarding achievement by students in poverty in one-to-one programs. Bixler (2019) also contributed helpful information to substantiate a gap for this study, but it was limited to three middle schools in a private school district. The author communicated a need for future research in a larger sample of schools to determine the best ways to increase achievement within a one-to-one environment. Weber and Becker (2019) provided information supporting the gap for this study. The authors documented a need for future research to investigate the use of Internet connected technology for school-related activities to determine if a connection exists with higher student achievement especially by students of low SES. Therefore, the research that needs to be better understood involves the impacts of one-to-one programs based on summative test data for students of low SES. The current study provided research information for this topic. This study analyzed secondary archived standardized test data for students of low SES to determine any statistical differences in achievement for low SES eighth-grade students based on years of participation in a one-to-one laptop program.

Current literature on the academic impacts of one-to-one programs as a means of addressing the problem of the digital divide, provide evidence both for and against the implementation of one-to-one programs in schools. The revolving dispute forms a gap that has yet to adequately examine the potential impacts technology funding has on student academic achievement (Bass, 2021). Additionally, there is a need for studies over time to clarify if academic impacts of one-to-one programs are worth the investment (Weber & Becker, 2019). This study addressed this need by examining the impact of a one-to-one computer program over a 3-year implementation period.

Conflicts in recent studies fuel the need for clear answers. Chou et al. (2017) researched the potential academic impacts of a one-to-one laptop program on reading and mathematics scores. Findings suggested no impact on mathematics or reading scores after 2 years. Additional support for the argument against investing in one-to-one laptop programs was presented by Hazlett et al. (2019). The authors found that while an increase in E-Rate funding positively increases the ratio of computers to students, the study generated no evidence to support one-to-one impacts on Scholastic Aptitude Test scores. Mora et al. (2018) presented data reflecting consistently negative impacts of one laptop per child on student performance in the areas of mathematics and language over a 7-year period. Conversely, Robinson et al. (2018) noted a positive correlation between academic achievement and duration of computer experience.

Additional support for the pro-one-to-one argument stems from the research of Chou et al. (2017). The findings support that computer literacy skills are a positive determining factor of school performance for students in Grades 7 to 12. This research corroborates the work of Robinson et al. (2018), noting that students lacking computer competence and skills will not be able to perform well academically. Based on conflicting evidence as to the educational impacts between educational ICT usage and academic performance, there is a need for future studies over time (Weber & Becker, 2019). The impact of one-to-one programs on the achievement of students of low SES needs further exploration as these students may be victims of the problem of the digital divide (Chiao & Chiu, 2018). The research on the topic of the digital divide as it impacts student achievement needs to be better understood (Chiao & Chiu, 2018; Weber & Becker, 2019). This study provided information relative to the impacts of one-to-one programs by examining a program in a Washington school district. This information can serve to add additional information for the current debate on this topic.

This research may be applicable to the target Washington school district, the state of Washington, and beyond by providing information to district leaders pertaining to the return on investment demonstrated by a one-to-one laptop program relative to student achievement. This study may be contributory to professional decision making by districts on whether to invest taxpayer dollars in one-to-one laptop programs. Hazlett et al. (2019) opined that future research should analyze metrics other than Scholastic Aptitude Test scores as student achievement may be revealed in other measures. This study analyzed 2016 and 2018 Smart Balanced Assessment Consortium (SBAC) summative ELA and mathematics scores for low SES eighth-grade students. The analysis will contribute information relative to the impacts of a one-to-one computer program on student achievement that can be used by school administrators and other education professionals. This study addressed what still needs to be learned about student achievement and one-to-one programs addressing the digital divide in education.

This research may have applications beyond the local setting for broader societal needs. The digital divide is a societal problem (Fang et al., 2019). Reducing the digital divide can be considered a benefit to society (Lanford, 2019). This study examined one school district's efforts to reduce the digital divide. This examination may provide information that is applicable to other settings and information that might be useful in reducing the digital divide and, consequently, benefiting society. This study may provide information to address the broader societal need of student achievement on high stakes SBAC summative tests in one-to-one laptop computer environments.

Deficiencies in the Evidence

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. This study examined the impact of a one-to-one computer program over a three-year implementation period. School districts have invested in learning tools including computers to provide more equitable access for students. The results of these investments based on empirical studies is mixed.

SES may be a contributing factor to academic achievement in a one-to-one environment. Further research is needed regarding student achievement by students in poverty (Bass, 2021) in one-to-one programs (Bixler, 2019). There is also a need for future research to measure the academic impacts of one-to-one programs on students' academic performances on standardized tests (Vu et al., 2019). Research by Robinson et al. (2018) called for additional research related to computers in the classroom and differing socio-educational realities of students. Chou et al. (2017) shared that while qualitative analysis of student achievement related to equitable access to computers has been demonstrated, quantitative research is lacking. Researchers have noted there are obvious gaps that are still not adequately addressed in contemporary research around one-to-one learning environments. The lack of quantitative research (Chou et al., 2017), and peer-reviewed literature of longer term studies focused on academic achievement creates a need for further investigation. This quantitative study was designed to address these gaps and provide information that could be useful in addressing the problem of the digital divide.

Audience

Information provided by this study will advance knowledge and practice relative to the problem of the digital divide. A significant contribution this study will provide is a test for the connectivism theory. According to Siemens (2005), connectivism is a learning theory that explains how technologies have created new opportunities for people to learn and share information across the World Wide Web and among individuals. The results of this study should provide information on statistical differences in learning based on access to technology, which aligns with the theory of connectivism. This study may also help school district decision-makers considering the return on investment of one-to-one laptop programs and potential impacts on student achievement. This information may be particularly interesting to school districts looking to address the problem space of the digital divide.

Setting of the Study

The setting for the study was one mid-sized, suburban public school district in the state of Washington. The school district, like the state, is both economically and racially diverse. Students are enrolled in prekindergarten through Grade 12 and include students from a wide variety of ethnic and socioeconomic backgrounds. The study focused on the pre-COVID-19 time period of 2015-2016 and focused on data for eighth graders. School district enrollment for the 2015-2016 school year was 11,331, and, in the 2017-2018 school year, school district enrollment was 11,294 (Office of Superintendent of Public Instruction, 2022). There were three middle schools within the district serving students in Grades 7 and 8. The study focused specifically on the eighth-grade students in the district. In 2015-2016, eighth-grade enrollment in the district was 353. In 2017-2018, eighth-grade enrollment in the district was 374.

Researcher's Role

The researcher was employed by the participating school district as a district-level Career and Technical Education director. The role of the Career and Technical Education director in the participating school district is to lead and support instructional programming in all career-related classes in Grades 7 to 12. The role includes evaluating staff and monitoring student progress, as well as gaining program approval from the state and ensuring that all classes meet state requirements to receive state funding. The director also oversees the program budget for all Career and Technical Education-related spending.

Purpose of the Study

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistically significant difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES who participated in a Washington school district's one-to-one laptop program for 1 year versus 3 years. The study was accomplished by utilizing archival secondary data for eighth-grade students of low SES.

The data examined in this study included SBAC summative ELA and mathematics achievement scores organized into four groups. There were two groups for each research question. Research Question 1 focused on ELA achievement, and Research Question 2 focused on mathematics achievement. Groups were established and compared based on time in a one-to-one laptop program: 1 year versus 3 years. The two groups that were compared for Research Question 1 were 2016 eighth-grade students of low SES (Group 1) who participated in the one-to-one laptop program for 1 year and 2018 eighth-grade students of low SES (Group 2) who participated in the one-to-one laptop program for 3 years. The two groups that were compared for Research Question 2 included 2016 eighth-grade students of low SES (Group 3) who participated in the one-to-one laptop program for 1 year and 2018 eighth-grade students of low SES (Group 4) who participated in the one-to-one laptop program for 3 years. The data were analyzed using an independent-samples *t* test as the analysis procedure to test each question's hypotheses and to determine the statistical significance of differences between groups.

Potential benefits for achieving the purpose of the study include the presentation of quantitative data on the impacts of one-to-one laptop computers on student achievement. In the era of COVID-19 and remote learning, study results could also provide important information to school decision makers on the return on investment impacts of one-to-one computer programs on state testing student achievement. In addition, the focus on middle school student achievement data in the areas of ELA and mathematics may provide useful information to school leaders considering the impacts of one-to-one laptop programs on ELA and mathematics learning mastery.

Definition of Terms

For the purpose of this applied dissertation, the following terms are defined.

Common Core State Standards (CCSS)

The Common Core State Standards (CCSS) are "a set of high-quality academic standards in mathematics and English language arts/literacy (ELA). These learning goals outline what a student should know and be able to do at the end of each grade" (CCSS Initiative, 2020, para. 2). Achievement of these standards is measured by the eighth-grade ELA and mathematics summative assessment, which was the instrument used to produce the secondary data to be used for analysis in the study.

Digital Divide

The digital divide is defined as unequal access to computers and the Internet based on economic status (van Dijk, 2006). The digital divide occurs when the Internet does not scale economically, creating a divide between the informational haves and have-nots (Hoffman & Novak, 1998).

English Language Arts Achievement

Achievement in ELA is measured by high-stakes test score data reported numerically, falling in ordered proficiency categories (Kuhfeld et al., 2019). ELA achievement was measured by SBAC summative scores as interval data. The measurement type was interval (scaled score range: 2288 to 2769).

Free School Meals

This term refers to school meals provided at no cost to students based on household incomes at or below 130% of the federal poverty level (Food Research and Action Center, 2020; Gajo et al., 2019).

Information and Communications Technology (ICT)

This term is a collective term for “stationary computers, laptops and tablets, Internet-connected or not” (Liabo et al., 2016, p. 3). ICT literacy is defined as an individual's ability to leverage ICTs to collect, investigate, manage, produce, and communicate digital information (Scherer & Siddiq, 2019).

Low Socioeconomic Status (SES)

This term refers to the determination of an individual's location in the societal hierarchy as one with the least amount of money, lowest education, and no respectable form of employment based on factual reporting as it relates to a shared public benchmark of SES (Tan et al., 2020). It involves status based on factual reporting of an individual's level of material possessions, indicated by income level, educational attainment, or a combination of both (Tan et al., 2020).

Mathematics Achievement

Achievement in mathematics is measured by high stakes test score data reported numerically, falling in ordered proficiency categories (Kuhfeld et al., 2019). Mathematics achievement was measured by SBAC summative scores as interval data. The measurement type is interval (scaled score range: 2265 to 2802).

One-to-One Laptop Program

One-to-one laptop programs are those in which each individual student is provided with a technology device, for the purposes of education (Lamb & Weiner, 2018). Students are learning in a school setting wherein all students have their own ICT, such as a laptop computer or tablet, for 24/7 access to the Internet, digital curriculum materials, and online textbooks (Vu et al., 2019). Years of participation in a Washington school district's one-to-one laptop program were measured at the nominal level. The measurement type was dichotomous: 1-year participation and 3-year participation. According to Hull and Duch (2019), years of participation in a one-to-one laptop program is defined as the sum of academic years of participation from the beginning until the end of the school's academic year during which students are exposed to a one-to-one laptop program.

Reduced Price School Meals

This term refers to school meals provided at reduced cost to students based on households with incomes between 130% and 185% of the federal poverty level (Food Research and Action Center, 2020; Gajo et al., 2019).

Smarter Balanced Assessment Consortium (SBAC)

The SBAC is a "public agency currently supported by its members. Through the work of thousands of educators, we created an online assessment system aligned to the Common Core State Standards (CCSS), as well as tools for educators to improve teaching and learning" (SBAC, 2022, para. 1). SBAC assessments are given at the end of the school year to measure student progress using a computer adaptive test and a performance task (SBAC, 2014a, 2014b; 2021; Smith & Wheeler, 2019).

Chapter 2: Literature Review

Introduction

The purpose of this quantitative, nonexperimental, causal-comparative study is to determine the extent to which a statistical difference exists in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Low SES is defined as the determination of an individual's location in the societal hierarchy as one with the least amount of money, lowest education, and no respectable form of employment based on factual reporting as it relates to a shared public benchmark of SES (Tan et al., 2020). The independent variable for the study involved years of participation in a Washington school district's one-to-one laptop program. The dependent variables were ELA achievement and mathematics achievement. The literature review examines current literature important to the study's topic and purpose.

Chapter 2 is organized into seven sections: introduction, theoretical foundations, a synthesis of the findings in regard to the problem area and other relevant topic areas for the study, future research, shortcomings and strengths, critique of the literature, and summary. The problem space for which background will be presented is the digital divide. The problem space of the digital divide highlights the gap between those with adequate ICT access and individuals with no, limited, or inconsistent ICT access (Rogers, 2016). Addressing the problem space of the digital divide in the context of a one-to-one laptop program in a public school will contribute to current literature.

In the theoretical foundations section, a discussion of Siemens' (2005) connectivism theory will be presented. This section will include a review of Siemens' connectivism theory, a learning theory for the digital age. Learning theories provide valuable insights about how learning takes place (Campbell et al., 2020). Connectivism theory is relevant for today's learning environments, as connectivism views learning as actionable knowledge that may reside outside of the learner as in a database platform or organization (Siemens, 2005). The selection of connectivism theory for this study may help to explain potential achievement differences in a one-to-one program.

The literature review will discuss topics relevant to the focus of this study. The major topics to be discussed will include the history of computers in education, computers and achievement, and the digital divide. The literature review is organized by topics to include the following: A Historical Perspective of Computers in Education, Legislation relative to Computers in Education, Computer Integration Models, Computers and Assessment, Computers and Achievement, and the Digital Divide. Chapter 2 will conclude with a summary. The summary for Chapter 2 will highlight information from all sections of Chapter 2. The Chapter 2 summary will include a summation of the introduction and background of the problem, theoretical foundations, and the literature review. This will include examples of key references for the research literature themes discussed.

Literature was surveyed leveraging an online library and multiple databases. The literature included a focus on recently published scholarly peer-reviewed articles and seminal sources. The libraries utilized included Grand Canyon University's online library and NOVA Southeastern University’s online library. Online databases utilized included ProQuest, Google Scholar, Education Research Complete, Education Resources Information Center, and Elton B. Stephens Company Host.

Theoretical Framework

Understanding the learning process is a significant consideration in the field of education. Learning theories provide valuable insights about how learning takes place (Campbell et al., 2020). Additionally, learning theories may help to explain reasons behind differences or changes in learning, and student achievement outcomes (Driscoll, 2000). Theories of learning clarify how the process of learning happens, providing direction for ways to address challenges and improve learning (Driscoll, 2000). The selection of connectivism theory for this study may help to explain potential achievement differences in a one-to-one program.

This study examined the topic of achievement differences based on years of participation in a one-to-one laptop program. Therefore, a theory relevant to learning, the digital age and the problem space of the digital divide, is essential as a foundation for the study. The theoretical foundation for this study involved Siemens' (2005) connectivism theory. Connectivism is a learning theory specific to the digital age integrating principles from chaos, network, complexity, and self-organization theories (Siemens, 2005). Connectivism is a learning theory specially designed to address the unique ways in which learning happens in contemporary classrooms. Siemens (2018) shared that learning in technology-rich environments is a process consisting of elements in perpetual motion, existing outside of the learner's control. Therefore, connectivism theory applies to learning happening in settings such as one-to-one program environments.

Historical Perspective of Connectivism

The three learning theories of behaviorism, cognitivism, and constructivism are frequently leveraged during the design process for instructional environments (Cates, 1993). These theories, while well developed and proven, were created well before classroom environments were impacted by ICT (Siemens, 2005). One-to-one learning environments are, historically, a relatively new concept (Zawacki-Richter & Latchem, 2018). Therefore, a contemporary learning theory that acknowledges the unique nature of learning taking place both inside and outside classroom walls today is appropriate.

On December 12, 2004, George Siemens unveiled his new learning theory on his personal website, calling it connectivism. The article was formally published in April 2005, specifying connectivism as "a learning theory for the digital age" (Siemens, 2005, p. 3). Siemens described previous learning theories as inadequate considering online social networks impacting learning, instruction, and the curation of information along with the novel impacts on day-to-day functioning. Siemens (2005) noted the need for a learning theory representative of principles and processes in contemporary social environments. Campbell et al. (2020) argued that the scope of change resulting from learning in the digital age is greater than that of previous learning theories. The argument forms the basis for the selection of the connectivism learning theory to explain the learning and achievement taking place in a one-to-one laptop program. From its inception, Siemens positioned connectivism as a learning theory capable of addressing the technological paradigm shift taking place across the institution of education.

Tenets of Connectivism

Connectivism theory posits that connecting specialized groups or sets of information between connection points or nodes, and the connections that make learning new information possible, are valued more than what is currently known. New information is consistently acquired despite evolving foundations from where decisions are made (Siemens, 2018). These tenets of connectivism theory demonstrate alignment with this study's specific problem of interest, which states that it is not known to what extent differences exist in eighth-grade ELA and mathematics summative assessment achievement outcomes for students of low SES based on years of participation in a Washington school district's one-to-one laptop program.

The implications of connectivism are meaningful for learning environments in today's classrooms. Connectivism theory redefines learning as previously known and holds implications for leadership and organizational management (Siemens, 2005). In the seminal publication online, Siemens (2005) denounced previous learning theories with a contemporary prospective that learning is directly connected to networking and ICT. Connectivism theory differs from other learning theories in that the concept of transferring, making, or building knowledge does not exist (Campbell et al., 2020). Instead, networks of groups or people develop through the process of incorporating information in meaningful ways, through authentic interactions with external resources (Campbell et al., 2020). In connectivism, the fabric of knowledge itself is made up of a chaotic network whereby any node can be connected virtually to any or all other nodes (AlDahdouh et al., 2015). Nodes that facilitate learning may be human or non-human, including people, information sources, or any entity with which a virtual connection may occur (AlDahdouh et al., 2015). Exploring the implications of connectivism theory related to student achievement will add to the body of literature on connectivism theory in education.

Learning may be impacted by ICT access and use. Connectivism thought leaders posit that ICTs make interactions between humans and information possible at a scale that is impacting learning beyond explanations provided by previous learning theories

(Campbell et al., 2020). Learning in an ICT-rich environment, according to connectivism theory, is that participation is not a by-product of participation (Campbell et al., 2020). ICT supported participation results in learning manifested as networks: cognitive, social, or conceptual (Campbell et al., 2020). Learning in a one-to-one program environment aligns with Connectivism as it includes both networking and ICT. This study will add to Connectivism Theory by testing the theory through an analysis of learning based on student achievement in a one-to-one environment.

Learning is about making connections. Siemens (2005) shared that learning is made up of a network of connections between human and non-human entities described as nodes. Non-human nodes include databases, the World Wide Web, information sources, ebooks, blogs, wikis, and chat portals. Connections between nodes may take the form of online feedback, interactions between individuals or groups of learners, the addition of comments to an online post, or the reading of online course content (Siemens, 2005). Individuals and groups create networks through the incorporation of knowledge curated through meaningful interaction with online sources.

Interactions between nodes are the foundation for learning in Connectivism. The process of curating and sharing knowledge through interactions between the Internet and humans serves as the foundation for learning (Campbell et al., 2020). Campbell et al. (2020) shared that ICTs enable interactions at the individual level between people and information, changing the way learning happens. When individuals and/or groups participate in activities supported by ICTs resulting in the formation of knowledge producing networks, learning occurs (Campbell et al., 2020). Learning in a one-to-one program is unique as it affords learners opportunities for making connections and experiencing interactions impossible without equitable ICT access.

Connectivism, Learning, and Achievement

Learning in today's technology rich world is changing rapidly. Specifically, the learning taking place in technology rich classrooms today is ever changing due to constantly evolving instructional and learning tools (Mora et al., 2018). Connectivism Theory is relevant for today's learning environments, as Connectivism views learning as actionable knowledge that may reside outside of the learner as in a database platform, online learning space, or organization (Siemens, 2018). For example, teacher online feedback increases learning by promoting students' learning attitude (Pan & Shao, 2020). Learning occurs when students interact online, making connections in their unique online interactive context (Pan & Shao, 2020). Connectivism Theory may provide a new perspective on how learning and achievement are impacted by the digital age (Natt och Dag, 2017). The educational impacts of technology should be better understood in order for educational systems to make educated decisions pertaining to short- and long-term investments.

The problem space of the digital divide relates to Siemens' (2005) Connectivism Theory as the theory was created to address learning in the digital age. Students without equitable ICT access are at a disadvantage and experience negative academic impacts as a result (Fraillon et al., 2019). This study will add to the body of literature on Connectivism Theory. Natt och Dag (2017) noted that current literature on Connectivism Theory holds significant potential for increasing understanding of learning in the digital era. There is a need for continued theory building and testing of Connectivism to increase understanding of the importance of examining learning in the digital age wherein individuals are immersed in an environment of receiving and accessing a constant flow of information (Natt och Dag, 2017). This study served as a test for Connectivism Theory. The research questions were used to justify the measurement of variables, including years of participation in a one-to-one laptop program and ELA and mathematics achievement scores.

Synthesis of the Findings

The review of literature will provide a broad, balanced overview of the existing literature related to the research topic of a comparison of achievement differences based on years of participation in a one-to-one laptop program. Computers have cultivated immense change in the way teachers are able to deliver instruction, and the ways students are able to learn (Hanimoglu, 2018). ICTs could be a significant factor in the key educational area of student achievement (Hanimoglu, 2018). Therefore, a thorough review of the literature will provide information relative to one-to-one programs and achievement.

Background to the Problem

The over-arching problem for this study involved the digital divide and resulting issues. The problem space of the digital divide has evolved historically from existing initially as a term used to describe technological inequality between developed and developing countries (Talaee & Noroozi, 2019). The problem space of the digital divide quickly transitioned from a country level focus to an individual level focus. Talaee and Noroozi (2019) explained this occurrence as the global divide which evolved into a social divide of digital exclusion for individuals and groups within countries. To decrease the resulting digital divide at the individual level, countries work to equalize ICT access for all citizens (Hohlfeld et al., 2008). Ubiquitous ICT access for all decreases the potential for the digital divide to persist.

Countries around the globe are focusing on infrastructure to ensure universal ICT service and universal ICT access for citizens. The goal is making basic ICT services and access to those services available to all individuals in order to decrease the problem of the digital divide (Hohlfeld et al., 2008, 2017). Universal service for example, focuses on ensuring that basic ICT services are available within homes (Hohlfeld et al., 2017). State-wide broadband service is an example of universal service that must be ubiquitous in order for students in urban and rural schools alike, to have equitable access. Today, digital divide represents the problem of individuals and groups of individuals experiencing digital exclusion (Talaee & Noroozi, 2019). The problem space of the digital divide has evolved from a broad view of technological inequality, to its current form which focuses on technological inequality experienced by individuals.

Identification of the Problem Space

The problem space for this study involved the digital divide. Digital divide refers to the widening gap that exists between the underprivileged including low SES individuals lacking access to computers or the Internet; and wealthy, or middle-class individuals with access (Talaee & Noroozi, 2019). The digital divide affects minorities and students of low SES as they are more likely to attend schools with significant budget deficits contributing to student deficits in digital skills. Talaee and Noroozi (2019) noted the digital divide as a problem depicting a state of society wherein a divide or experienced inequality occurs as a result of technology's existence. For purposes of this study, the term digital divide will be operationally defined as unequal access to computers and the Internet based on economic status (van Dijk, 2005, 2006; van Dijk & Hacker, 2003). Definitions of the digital divide vary by application level, and range from inequitable access across countries to computers and the Internet (Rogers, 2016), to the lack of broadband data transmission specifically in rural and poor urban areas (Graham, 2011), to the gap separating individuals in pockets of society as the information haves from the information have-nots (Eubanks, 2007). The digital divide can negatively impact individuals of low SES, perpetuating societal inequality. Therefore, a focus of this study involved students of low SES.

There has been much discussion and consensus about impacts of the digital divide on society. However, there is no consensus on who, specifically coined the phrase digital divide. According to Rogers (2016), the digital divide was coined collectively by New York Law School professor, Allan Hammond, and National Telecommunications and Information Administration member, Larry Irving in 1995. Conversely, Hoffman and Novak (1998) credited Lloyd Morrisett, former president of the Markle Foundation and founder of the Sesame Street Workshop, with being first to utilize the phrase in 1996. The definition provided by Morrisett helps to operationalize the term digital divide. Morrisett's definition includes that the digital divide occurs when the Internet does not scale economically, creating a divide between the informational haves and have-nots (Hoffman & Novak, 1998). Eubanks (2007) contributed that Morrisett himself expressed doubts about the origin of the term, digital divide. In addition, Rogers noted that, originally, it was the Clinton administration that defined the digital divide as inequitable access to computers and the Internet.

The problem space of the digital divide is broad, and there is much that is known about the digital divide. Impacts of the digital divide range from a global perspective to a national perspective. According to Pick and Nishida (2015), the globe has a digital divide representing differences among countries in the areas of technology utilization and accessibility, economic levels, and governmental support. At the national level, digital divide impacts affect provision of technology services within a country, its available e-commerce platforms, economic export abilities, and political uprising and unrest resulting in national discrepancies in available technology and infrastructure (Rogers, 2016).

Van Deursen and van Dijk (2019) are key sources documenting the problem space of the digital divide. For many years, policy-makers believed that the digital divide would subside with country-wide Internet saturation (van Deursen & van Dijk, 2019). Further research began to surface claiming that the problem of the digital divide stemmed from successive types of ICT access (van Deursen & van Dijk, 2019). Successive types of ICT access include an individual's motivation to access ICTs, the ability to physically access ICTs on a consistent basis, an individual's digital skill level in leveraging the ICT to meet basic needs, and different usage of ICTs in daily life (van Dijk, 2006). Documenting the problem space of the digital divide takes into account trends in research. Trends in research document the expansion of the problem space of the digital divide. The digital divide expanded to emphasize impacts on an individual's position in society, rather than focusing on ubiquitous country-wide Internet access as the root of the problem (van Deursen & van Dijk, 2019). Individuals using different ICS have different experiences as not all ICTs afford the same quality of online participation (van Deursen & van Dijk, 2019). Exploring trends in digital divide research brings to light key findings.

Key findings emerging from recent studies confirm that digital divides continue to broaden despite universal physical access to ICTs (van Deursen & van Dijk, 2019). Individual level impacts evidenced by reduced participation in society are key findings in helping to increase current understanding of the digital divide (van Deursen & van Dijk, 2019). Scholars researching the digital divide and successive types of ICT access have concluded that the digital divide evidenced by an individual's lack of Internet skills and varying kinds of use continue to grow even though universal ICT access may exist (van Deursen & van Dijk, 2019). Researchers have concluded that other barriers arise for individuals impacted by the digital divide, even when they have ICT access (van Deursen & van Dijk, 2019). Barriers include that individuals may not have access to the same quality devices, peripherals, opportunities afforded through a device, and that ongoing ICT related expenses affect ICT skills, usage, and potential outcomes (van Deursen & van Dijk, 2019). Despite evidence supporting great improvements in physical access to ICTs, barriers for individuals impacted by the digital divide remain.

Digital Divide

Digital divide research relative to the dissertation problem space of the digital divide in K-12 education is explored in this section. Understanding the digital divide as it pertains to K-12 education systems will provide information specific to the overall dissertation topic of achievement differences of students with low SES, based on years of participation in a one-to-one laptop program. Understanding the current literature on the digital divide as it pertains uniquely to K-12 schools will add to the literature and provide information for school districts. Understanding the three levels of the digital divide in the K-12 educational system context is relative to the overall dissertation topic as understanding the impacts of the digital divide on students in schools provides background understanding for the dissertation topic.

History of the Digital Divide. The concept of the digital divide has been applied to various situations over the years, starting first with a focus on the technological divides evident between developed and developing nations (Talaee & Noroozi, 2019). The concept then evolved, narrowing to the regional level (Rogers, 2016; Setthasuravich & Kato, 2020). The digital divide research has further evolved to represent the disparity at the individual level, described as the haves with reliable ICT access, and the have nots, as individuals impacted negatively by digital inequality (Hohlfeld et al., 2017). Digital inequality is a type of social inequity specific to ICT access, ICT user skills, and holds complex social implications for individuals, exacerbated by factors unique to those on the wrong side of the digital divide (Hohlfeld et al., 2017). The wrong side of the digital divide encompasses both ICT access and the individual user.

Traditionally, research on the digital divide has focused on ICT access and with time, a deeper understanding has evolved (Hohlfeld et al., 2017). Van Dijk and Hacker (2003) noted the digital divide centered on differences at the individual level, in user motivation, ICT skill set, and ICT usage. Van Deursen et al. (2017) suggested individuals impacted by the digital divide may experience digital exclusion in sequential and compounded ways. Yu (2006) shared a three-level hierarchical system of digital divide factors that extended the original research focus beyond ICT access, to factors impacting the societal, community, and individual levels. The digital divide persists as a problem in the United States to include skills, knowledge, and dispositions of individuals impacted by digital inequality (Hohlfeld & Ritzhaupt, 2018). A problem identified as the digital divide impacts all levels of society including education.

Digital Divide in K-12 Education. The digital divide in K-12 education has broad reaching impacts for student access to ICTs, as well as the way ICTs are leveraged for learning. Ensuring participation in the digital aspects of society affords individuals access to the unique benefits technology has on social participation and wellbeing throughout life (Fang et al., 2019). Current digital divide research supports that the digital divide impacts society as a whole, and as a result the digital divide impacts K-12 schools (Hohlfeld et al., 2017). The Levels of Digital Divide in Schools conceptual framework

(Hohlfeld et al., 2008) organizes three key levels of the digital divide as they pertain specifically to the K-12 education system as opposed to a broader societal view (Hohlfeld & Ritzhaupt, 2018). The three key levels of the digital divide as described by Hohlfeld et al. (2008) and Hohlfeld et al. (2017) are examined in this section of the literature review. Levels of the digital divide in education are examined next.

Levels of the Digital Divide in K-12 Education. From many perspectives, the digital divide is considered a new gap in the K-12 educational system, with negative impacts widening existing achievement gaps (Hohlfeld & Ritzhaupt, 2018). Hohlfeld et al. (2008) shed light on the complex nature of the digital divide in K-12 education in their seminal work on ICT literacy in Florida schools. The authors proposed a three-level pyramid model of the Levels of Digital Divide in Schools consisting of school infrastructure, classroom, and individual student empowerment.

Level 1, school infrastructure, indicated that the digital divide inequality experienced by students lies in the areas of access to both hardware and software, Internet access, and support for technology (Hohlfeld et al., 2008). Level 2, classroom, focuses on the disparate frequency and purpose of ICT use by teachers and students (Hohlfeld et al., 2008). Level 3, individual, is the top level of the pyramid wherein students experience unequal opportunities for empowerment made available through access and educational applications of ICTs (Hohlfeld et al., 2008).

Inequities become increasingly personal to the students as they ascend the three levels of the pyramid presented in the Levels of Digital Divide in Schools. The first level applies to inequities felt at the school community level, at the second level inequities are felt by teachers and students at the classroom level, and at the third and uppermost level inequities are experienced personally by the individual student (Hohlfeld et al., 2008).

Each level is contingent upon the minimal requirements of the previous level being met (Hohlfeld et al., 2017). For example, without adequate infrastructure, students and teachers are not able to use technology at the classroom level (Hohlfeld et al., 2017). The three levels of digital divide in education presented by Hohlfeld et al. (2008) as the Levels of Digital Divide in Schools, will be explored in this section of the literature review.

Level 1: School Infrastructure. The foundational layer of the Levels of Digital Divide in Schools pyramid is referred to as Level 1: School Infrastructure. Level 1 includes all things pertaining to school infrastructure such as access to both hardware and software, Internet, and available technical support serving the technology currently in place (Hohlfeld et al., 2008). Level 1 highlights a school's ability to provide equitable ICT access, as well as its ability to maintain both infrastructure and the ICT devices themselves (Hohlfeld et al., 2008). Disadvantaged schools, those with prevalent SES gaps, experience infrastructure and access challenges that promote a limited quality of education (Hosszu & Rughiniș, 2020). Neuman et al. (2018) shared results from a metanalysis including 100,000 students and 74 independent samples wherein a school's SES was found to have a greater deleterious effect on student achievement than individual student SES. Therefore, the reminder of the Levels of the Digital Divide in K-12 Education section focuses on the implications of unequal ICT access for students of low SES.

Disproportionate access to infrastructure impacts both the quality of, and access to ICTs for students of low SES. Hosszu and Rughiniș (2020) reported recently on the effects of COVID-19 and ICT access for students from disadvantaged schools in Romania. It was reported that between 250,000 and 900,000 students lacked access to online education due to the SES of their school (Hosszu & Rughiniș, 2020). In addition, Black students in low SES areas of Toronto are impacted by barriers to learning stemming from COVID-19 and remote learning (Allen et al., 2020). Black students face educational disparities as they often attend low SES schools, lack access to ICTs, and experience little to no parental support with remote learning (Allen et al., 2020). Students of color experience higher rates of poverty, overcrowding in homes, and inconsistent Internet access (Allen et al., 2020). Disproportionate ICT access is also experienced by individuals in poor countries.

The Level 1 digital divide remains a problem for individuals of low SES even in the richest and most advanced countries like the United States (Talaee & Noroozi, 2019; van Deursen & van Dijk, 2019). The Level 1 digital divide impacts basic physical access, material access, and the ongoing costs associated with ICT upkeep, licenses, and subscriptions. These barriers all exacerbate existing inequalities for individuals of low SES (van Deursen & van Dijk, 2019). Barriers to equitable ICT access are felt at the individual level when schools are not able to provide equitable ICT access for all learners (Buda, 2020). The digital divide remains persistent when schools are unable to provide adequate infrastructure and coursework necessary to develop the ICT skills of students of low SES. Students from disadvantaged schools may be impacted greatly as they have less access to adequate infrastructure than students from higher SES schools.

Level 2: Classroom. The second layer of the Levels of Digital Divide in Schools pyramid, classroom, addresses the frequency at which students and teachers utilize technology for instruction and learning (Hohlfeld et al., 2008). Level 2 highlights how regularly various types of technology such as online assessments, tutorials, and so forth are leveraged for the purpose of learning (Hohlfeld et al., 2008). The frequency and purpose of ICT integration into instructional practices for curriculum implementation is at the core of Level 2 (Hohlfeld et al., 2008, 2017). Level 2 includes that students learn from core curriculum while engaged with computers.

During instruction, students learn how to leverage technology for personalization, collaboration with peers, and to develop skill fluency in ICT for application (Hohlfeld et al., 2017). Developing these skill sets prepare students for success as they progress across levels to the empowerment level of the digital divide (Hohlfeld et al., 2017). Liu et al. (2017) implemented a multilevel path analysis model in their research to determine the influence of school-related variables on a teacher's use of ICTs, resulting in classroom ICT integration. Data were collected from 336 schools from 41 districts. There were 1.235 K-12 teachers who participated, and results suggested that a teacher's comfort level and experience with ICTs was related to the frequency with which ICTs were used in the classroom (Liu et al., 2017). Teacher experience and comfort with ICTs in part, determines students' access in class, to ICTs for learning (Liu et al., 2017). Liu et al. noted a need for future research to examine other variables relevant to ICT integration in K-12 settings.

Research by Karlsson (2020) examined the association between ICT use and test scores among students in different countries. Karlsson found a negative association between daily, weekly, monthly, and never ICT use at school, and test scores. Socioeconomic factors were taken into account and were determined to be only weakly correlated with test scores, as students of low SES tend to use ICTs for remedial purposes or skill and drill. Conversely, students of high SES are more likely to be enrolled in advanced technology courses and leverage ICTs for creation and innovative tasks. Future research should explore investments focused on reducing the digital divide.

Level 3: Individual Student. The third level of the Levels of Digital Divide in Schools pyramid, individual student, addresses how ICTs are used to empower the individual student (Hohlfeld et al., 2008), specifically whether the student knows how to utilize ICTS to improve their quality of life and which skills to apply in various contexts to accomplish personally valuable objectives (Hohlfeld et al., 2008). Level 3 of the Levels of Digital Divide in Schools highlights opportunities that allow students to apply previously developed knowledge and skills (Hohlfeld et al., 2008). The three levels of digital divide in schools afford students the opportunity to move from level to level applying the skills learned at the previous level.

Mastering ICT skills in Level 2 positions students to apply ICT skills with fluency in Level 3 for purposes of individual empowerment (Hohlfeld et al., 2017). ICT skill mastery happens through a process of developing and honing skills through learning experiences afforded by Levels 1 and 2 (Hohlfeld et al., 2017). At Level 3, students seamlessly transition between pencils and ICTs, applying knowledge and skills learned in meaningful ways, through support and mentoring of their teachers (Hohlfeld et al., 2017). Students from schools with inadequate infrastructure, and classrooms without regular ICT skill practice are at a disadvantage for developing an empowerment skill set. The Levels of Digital Divide are hierarchical, building one upon another, positioning students at Level 3 to apply ICTs in daily life for individual empowerment (Hohlfeld et al., 2017). Application of the three levels of digital divide in a daily context is the goal of the levels.

ICT literacy is defined as an individual's ability to leverage ICTs to collect, investigate, manage, produce, and communicate digital information (Scherer & Siddiq, 2019). Scherer and Siddiq (2019) conducted a meta-analysis to determine the relation between SES and students' ICT literacy skills. The authors utilized three-level random-effects modeling, done across 32 independent K-12 student samples of performance-based assessments of ICT literacy (Scherer & Siddiq, 2019). A positive and significant correlation to SES was found (Scherer & Siddiq, 2019). Study findings suggested that students' ICT literacy differs between SES groups (Scherer & Siddiq, 2019).

Demographics, including race and family of origin, are related to the digital divide; however, SES remains the greatest individual-level component in current research on ICT use. Hohlfeld et al. (2017) shared research on the ICT knowledge and ICT performance skills of students in middle school. The authors reported that students of high SES possessed higher achievement levels of ICT literacy skills than students of low SES. Students of low SES focused more frequently on drill and practice, limiting their ability to apply ICT skills for critical thinking activities and self-directed learning for empowerment (Hohlfeld et al., 2017). SES is, therefore, a contributing factor to ICT literacy skills.

Students enrolled in high-SES neighborhood schools in the United States are 1 year ahead in ICT skills including online research and comprehension skills compared to students attending low SES neighborhood schools. Students of lower SES are more likely to use ICTs for social media and gaming than for educational ICT skill development. Therefore, students of lower SES are less prepared academically than students of higher SES. In addition, the SES gap in ICT skills and use may exacerbate preexisting educational and social inequality.

Weber and Becker (2019) performed a quantitative study using descriptive statistics. The sample size included 154,539 high school students from 7,064 schools across 25 countries (Weber & Becker, 2019). The authors examined the association between parental SES, and high school students' Internet usage specifically for educational tasks (Weber & Becker, 2019). Study results indicated that students from homes with more books, and parents having higher SES, used the Internet more frequently for school related activities including academic Internet searches and Internet sharing, than students from low SES (Weber & Becker, 2019).

The Need for Further Digital Divide Research

The problem space of the digital divide has evolved over time, impacting trends in research. Digital divide studies have documented effects the problem space of the digital divide has had on the research including conflicting study results on whether narrowing the digital divide impacts student achievement (Anderson & Perrin, 2018; Rebmann et al., 2019; Scherer & Siddiq, 2019). Digital divide historically focused on large scale availability of technology between countries (Talaee & Noroozi, 2019). However, the problem space of the digital divide has evolved and is now closely connected with the technology needs of individuals within society and resulting societal impacts (Talaee & Noroozi, 2019). The digital divide problem space impacts research trends as current studies call for future research on student achievement.

The evolution of the digital divide has expanded to include research focused on societal impacts. It is understood that the digital divide impacts many facets of society from equitable access to technology for learning, to one's ability to access services and basic needs. The digital divide depicts the state of society as it pertains to available technology and the ability of individuals to maintain connectivity (Putri et al., 2020). Much has been discovered about societal impacts of the digital divide from key sources, including negative impacts on children from low SES, being less likely to have access to Internet connected technology than non-poor peers (Talaee & Noroozi, 2019). The digital divide impacts all members of low SES households, from children with needs for ICT to support education (Anderson & Perrin, 2018), to adults needing consistent access to maintain active societal interaction (Reddick et al., 2020), to the elderly who may be isolated due to the digital divide (Fang et al., 2019). The digital divide can impact individuals of low SES from all ages and genders.

Questions remain specific to the digital divide and what needs to be understood about the impacts of the digital divide on student achievement. This study will address the research problem space identified by key sources identifying the need for future research to measure the academic impacts of one-to-one programs on students' academic performances on standardized tests (Vu et al., 2019). Future research is needed regarding student achievement by students in poverty (Bass, 2021) in one-to-one programs (Bixler, 2019). Physical access to ICTs should be the primary concern of every government as computers can narrow or close both knowledge poverty gaps, and economic gaps (Setthasuravich & Kato, 2020). Trends in research will be examined to present current impacts of the digital divide on student achievement.

Trends in the evolution of digital divide research and literature on the digital divide previously centered around a lack of access to Internet networks, and a push for expansion of Internet service across countries (Talaee & Noroozi, 2019; van Deursen & van Dijk, 2019). The focus on Internet expansion is likened in importance to that of a country's nervous system. The research focus has changed over the recent past from a focus on expanding Internet and infrastructure to the impacts of the digital divide on the lives of individuals and societal groups. Despite ever expanding networks across the globe, a digital divide persists (Rogers, 2016), as low SES often prevents individuals from accessing available networks. The negative impacts resulting from the digital divide are present at the individual and societal levels.

Research on the evolution of the digital divide provides that the digital divide stems from a series of factors including the drive to have ICTs, provide ICTs, the ability to use ICTs, and forms of ICT utilization (Rogers, 2016). The problem space of the digital divide is explained through the evolution of digital divide research. The evolutionary change in digital divide research has transitioned from an Internet focus to the individual level is due to glaring societal effects on quality-of-life impacts of the digital divide. Research highlights the digital divide link between low-income status and access to ICTs (Hohlfeld & Ritzhaupt, 2018). Low-SES individuals may have limited Internet, sub-par bandwidth for use by multiple individuals within a home, antiquated ICTs, or only a smart phone with limited minutes (Lanford et al., 2019). Many factors contribute to the negative experiences of individuals of low SES as they navigate the digital divide and its impacts on quality of life.

The evolution of digital divide research includes an increased focus on societal impacts. Putri et al. (2020) noted a state of society wherein inequality exists due to unequal distribution or the lack of equitable access to technology as the digital divide. Active participation in society is a fundamental need requiring ICT access in today's digital society (Fang et al., 2019). Technology is part of the fabric of everyday life for the developed world whether an individual is excluded from access, or not. Unique benefits to social participation and wellbeing exist when technology is present; therefore, digital inequities must be irradicated (Fang et al., 2019). For individuals of low SES, digital inequalities may exist beyond the home.

Evolution of digital divide research includes the idea that a combination of factors may cause a digital divide within a school setting. Well-meaning schools with limited funding hoping to embrace technology may unknowingly widen the digital divide gap.

Potential antecedents promoting a digital divide in schools include BYOD models (Chou et al., 2017), technological tracking (Lanford et al., 2019), and digital bind models (Robinson et al., 2018). Investments in one-to-one laptop programs are an attempt by some school districts to narrow the digital divide.

Shortcomings to Avoid and Strengths to Repeat

The current study served to provide information related to the problem space of the digital divide. This was accomplished by examining differences in student achievement based on years of participation in a one-to-one laptop program designed to reduce the digital divide. The specific problem of interest for this study was that it was not known to what extent differences exist in eighth-grade ELA and mathematics summative assessment achievement outcomes for students of low SES based on years of participation in a Washington school district's one-to-one laptop program. The findings of research studies and evolution of recent literature (Bass, 2021; Bixler, 2019; Lanford et al., 2019; Rizk & Davies, 2021; Vu et al., 2019) have defined the parameters for the problem statement.

Parameters for the problem statement were shared by Lanford et al. (2019) as a need for a clearer understanding of digital participation and student learning when devices, designed to reduce the digital divide, are provided by the school. Future research is needed to examine whether and how digital technology can foster achievement, and whether it can nurture deep learning (Rizk & Davies, 2021). Vu et al. (2019) described parameters including that future research should seek to measure the academic impacts of one-to-one programs on students' academic performance on summative tests. Additionally, future research on student achievement by students in poverty (Bass, 2021) and in one-to-one programs (Bixler, 2019) is necessary. Much has been discovered about the digital divide and its social and societal impacts on individuals (Talaee & Noroozi, 2019). The topic of the digital divide as it impacts student achievement needs to be better understood.

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. This study analyzed low-SES students' secondary archival standardized computer adaptive test achievement data over the course of 3 years for ELA and mathematics. The digital divide excludes vast social groups from mainstream society (Kupriyanova et al., 2019). Therefore, this study may provide useful information about the potential role schools may play in reducing the digital divide.

Research focused on the problem space of the digital divide as it relates to student achievement will contribute to the body of literature. The current study will contribute to the body of literature on the digital divide by exploring the potential impacts a one-to-one laptop program may have on student achievement. Currently, there is no clear consensus in the literature to support or refute the impacts of one-to-one programs on student achievement (Mora et al., 2018). Future research to assess potential impacts of comparing standardized test scores at the same school before and after a one-to-one laptop intervention is needed (Meyer, 2017). A recommendation for future research is to conduct a formal evaluation of a one-to-one laptop program, evaluating students' academic performance on summative tests (Vu et al., 2019). An additional recommendation for future research is to analyze achievement of students in poverty (Bass, 2021) and in one-to-one programs (Bixler, 2019). This study will address the call for further digital divide research pertaining to academic achievement on summative tests, students of low SES, and one-to-one laptop programs.

Potential professional applications from this research may include information to better inform educators on the potential impacts that one-to-one laptop computers may have on student achievement (Reimer et al., 2021). Additionally, knowing the academic impacts will help to inform school district decision makers on the value of the one-to-one investment. The recent COVID-19 pandemic has greatly impacted the learning of children from disadvantaged families and highlighted the problems associated with the digital divide. This research may help to inform educators on the impacts of equitable ICT access on student achievement. Currently, students of low SES are receiving far less academic support during the pandemic from parents and experiencing reduced access to learning resources including ICT (Reimer et al., 2021). Study results from this study may inform educators about the potential impacts of providing equitable, one-to-one ICT access on student achievement.

Issues result from the problem of the digital divide. These issues include economic impacts, societal impacts, quality of life impacts, and educational impacts (Pérez-Castro et al., 2021; Rogers, 2016; van Deursen & van Dijk, 2019). The economic, societal, quality of life, and educational issues that individuals experience in being excluded offline correspond to issues in which those same individuals experience digital exclusion online (van Deursen & van Dijk, 2019). Issues resulting from the problem of the digital divide may impact individuals on personal and societal levels.

Individuals may experience exclusion from society as a result of the digital divide. ICT has evolved into a critical global infrastructure (Setthasuravich & Kato, 2020) from which some individuals may be excluded. A lack of ICT connectivity means exclusion from opportunities both on and offline. Opportunities individuals may be excluded from include opportunities for employment, education, healthcare and information (Cancela, 2020). Exclusion from opportunities to have basic needs met can be problematic for individuals impacted by the digital divide.

The digital divide may perpetuate exclusion both offline and online. Exclusion is due to the transfer of human capital carryover between online and offline worlds (van Deursen & van Dijk, 2019). Exclusion from employment relates to economic issues, exclusion from education relates to societal issues, and exclusion from health care related services and information relates to quality of-life issues. ICT infrastructure allows for the dissemination of important policy and public service information from the government to individuals (Setthasuravich & Kato, 2020). Individuals impacted by the digital divide are excluded from participating fully in economic and social opportunities that should be available to all (Cancela, 2020). Exclusion from participation in society may negatively affect quality of life as exclusion restricts basic opportunities for individuals of low SES.

Economic Issues

Economic status is an issue linked to the digital divide. Individuals impacted by the digital divide typically possess lower levels of education, may be unemployed, lack basic ICT skills, and are ill-equipped to engage in online activities that promote personal economic increase (van Deursen & van Dijk, 2019). Disparity exists as not all individuals in society can afford uninterrupted access to ICTs and Internet services calling for policy change at the national level (Cancela, 2020). Economic-related ICT uses include income-related activities such as online savings, investments, and earnings. In addition, employment related uses include ICTs for productivity, promotions, accessing employment opportunities, and online job opportunities. ICT economic uses also include finance tasks like investments, contracts, and accessing education opportunities and grades (van Deursen & van Dijk, 2019). The ability for individuals to use ICTs for life and work without barriers may increase economic status. Increases in economic status may relate to improved quality of life. ICT use for economic gain has the potential for economic promotion and benefit (Cancela, 2020).

Recent impacts of the COVID-19 pandemic solidify the importance of ICT access and the digital economy (Cancela, 2020). Individuals with ubiquitous ICT access, capable of leveraging ICTs for economic impact, have the capacity to develop increased economic, social, cultural, and personal capital (van Deursen & van Dijk, 2019). However, individuals of low SES are more likely to utilize ICTs for leisure activities and consumption (van Deursen & van Dijk, 2019). Equitable ICT use may positively impact quality of life and economic status for individuals of low SES.

The economic issue of ICT use for economic advancement increases financial opportunities and resources for career, educational, and societal advancement (van Deursen & van Dijk, 2019). The higher one's level of education, the more likely they are to access and leverage ICTs for advancement (Fang et al., 2019). Although ICT prevalence continues to progress quickly, many people around the world cannot afford Internet access due to economic poverty (Setthasuravich & Kato, 2020). Constrained by what they can or cannot access online based on their particular type of ICT and level of connectivity, individuals impacted by the digital divide may struggle to fill out and submit a job application (Rogers, 2016). The inability to access employment opportunities can impact the economic status and earning potential of individuals effected by the digital divide.

Societal Issues

Societal issues resulting from the digital divide are vast. The digital divide impacts societies as individuals without reliable ICT access are at a disadvantage within that society (van Dijk, 2006). Societal structures are designed by and for the socially advantaged, creating differentiated access to digital resources (Fang et al., 2019). Without access to up-to-date information and resources, individuals progressively lag further behind, excluding themselves from large parts of society (van Dijk, 2006). Research on the digital divide notes that different social groups have different online access to technology, contributing to and impacting societal advantages and disadvantages experienced offline (Chen & Bonanno, 2020). Societal issues pertaining to the digital divide may result in significant social exclusion and reduced societal position.

The digital divide effects the societal position of individuals of low SES. Achievements including occupying positions of power and building relationships become impossible for those excluded from society due to the digital divide (van Dijk, 2006). Exclusion further reduces opportunities available to individuals (van Dijk, 2006). Isolation increases for excluded individuals, making them less likely to participate in society and receive benefits of resources available through technology platforms. Structural inequality resulting from the digital divide includes exclusion from both social and media networks for 50% to 60% of the population (van Dijk, 2006). There is a need for action to address the detriment occurring when approximately half of a population is impacted by the negative effects of exclusion related to the digital divide.

The digital divide may perpetuate the societal gap between social classes. It clearly separates the haves from the have-nots in society (Hohlfeld et al., 2017). Therefore, an information elite begins to emerge in developed societies (van Dijk, 2006). The elite enjoy full and overlapping social and media network structures allowing them access to the best jobs and positions within society (van Dijk, 2006). However, individuals impacted by the digital divide typically access ICTs for entertainment but less frequently for accessing necessary social supports and resources (van Dijk, 2006). Individuals separated from the full benefits available in a society due to the digital divide may be negatively impacted.

Within society, individuals impacted by the digital divide become isolated. Individuals therefore, receive less exposure to technology, become socially isolated, and are less likely to use ICTs for communication (Chen & Bonanno, 2020). Individuals impacted by the digital divide are less likely than affluent members of society to receive assistance from family and friends when technical problems arise (Chen & Bonanno, 2020). These individuals impacted by the digital divide are also less likely to be influenced to use technology by peers. Peer influence impacts everything from substance use to ICT use via modeling and encouragement (Chen & Bonanno, 2020). Decreasing the digital divide may also decrease social isolation.

Quality of Life Issues

Quality of life issues resulting from the digital divide include health. Good health is critical to overcoming social disadvantage (Pérez-Castro et al., 2021). Governments with limited resources tend to provide unequal healthcare distributions to individuals impacted by the digital divide (Pérez-Castro et al., 2021). Technological advances hold the potential to increase life expectancy and positively impact mortality data for individuals (Pérez-Castro et al., 2021). The positive health impacts of a decreased digital divide may be an integral part of a healthy, functioning society.

The digital divide impacts the quality of life of individuals. Leveraging ICTs may help in the fight against deadly viruses through data collection, sharing, and analysis (Pérez-Castro et al., 2021). Without access to pertinent health information, individuals without reliable ICT access may experience reduced quality of life. For example, ICTs can be utilized in the identification and treatment of victims exposed to deadly viruses (Pérez-Castro et al., 2021). ICTs can also be utilized for accessing mobile health services and information (Pérez-Castro et al., 2021). However, not all individuals have equitable access to these resources and services as a result of the digital divide (Pérez-Castro et al., 2021). Individuals impacted by digital inequality may struggle with accessing a variety of resources (Rogers, 2016). Quality of life issues may be increased with the decrease of the digital divide at the individual level.

Quality of life includes participation in society. Issues of the digital divide exclude vast social groups from mainstream society (Kupriyanova et al., 2019). Lack of access to online social resources prevents group membership and sharing with a broader community. Quality of life impacted by the digital divide affects an individual's ability to participate in political systems, including voting, advocacy groups, expressing opinions and concerns within a community, and the opportunity to influence others (van Deursen & van Dijk, 2019). Those marginalized by the digital divide may be vulnerable to quality-of-life issues related to the digital divide.

The digital divide can negatively impact quality of life for marginalized populations. Disadvantaged social groups impacted by the digital divide such as racial and ethnic minorities and individuals of low SES experience accumulated disadvantage (Chen & Bonanno, 2020). Their quality of life is impacted as they are forced to rely on informal communication and information channels offline, due to the digital divide (Chen & Bonanno, 2020). Online communication and information channels build on common interests, shared activities, or family relationships (van Deursen & van Dijk, 2019). Individuals impacted by the digital divide are excluded from a sense of online community provided by reliable ICT access, and support from others that accompanies an online community (van Deursen & van Dijk, 2019). Minorities and individuals of low SES may face negative quality of life impacts related to the digital divide at a higher rate than their higher SES neighbors within the same population.

Educational Issues

Individuals of low SES may experience reduced quality of life when education is impacted by the digital divide. Talaee and Noroozi (2019) conceptualized the digital divide as a family's low SES status and lack of ownership and access to ICTs and the Internet. The authors explained that children with low SES status, from working class families, or those who reside in rural areas are likely caught in the digital divide. Low SES families caught in the digital divide may not own a home computer or have consistent access to the Internet despite living in privileged countries like the United States (Talaee & Noroozi, 2019). Research in this section examines the effects of the digital divide on ICT integration and access, and student achievement.

Powers et al. (2020) performed a mixed-method study to examine whether the Technology Acceptance Model contributed to the integration of one-to-one computers in instruction with the goal of decreasing the digital divide. The study included a sample size of 46 teachers from a small rural school district in Florida. The study employed the theory that posits that both perceived ease of ICT use and ICT usefulness may impact actual ICT use, decreasing the digital divide (Powers et al., 2020). The study concluded that both perceived ease of ICT use and ICT usefulness of one-to-one ICTs were predictors of one-to-one ICT use by teachers both in whole class and individualized instruction (Powers et al., 2020). Rural students experience the digital divide as they may have fewer opportunities for ICT access than urban and suburban students (Powers et al., 2020). Disparities in rural ICT access exasperate the digital divide in lower SES of rural school contexts (Powers et al., 2020). The study considered various ways in which teachers integrated one-to-one ICTs into instruction and what motivated them to integrate ICTs. The study analysis provided that assessment, digital literacy development, and collaboration were motivating factors for instructional ICT integration (Powers et al., 2020). Teachers noted reasons why they integrated as perceptions of increased engagement and personalized learning for students, as well as increased productivity for teachers. Future studies could include a larger sample size to afford the analysis of digital divide in smaller subsets of teachers to examine potential differences in one-to-one use by grade level (Powers et al., 2020). Additional studies could include observations of instruction with one-to-one compared to results from self-reported use data (Powers et al., 2020).

Hohlfeld et al. (2017) conducted a research study to examine the digital divide and ICT integration in Florida schools. Using descriptive statistics, Hohlfeld et al. included internal consistency reliability, exploratory factor analysis, and multi-level models to examine various ICT integration patterns over the course of seven years, occurring by SES in K-12 schools in Florida. The study included Technology Resources Inventory responses submitted by principals and technology coordinators for a sample size of 67 Florida public school districts. Annually, Florida school leaders submit Technology Resources Inventory surveys providing information about the ways in which technology is integrated at their school. The study examined the relationship between technology integration patterns, SES, and school type (Elementary, Middle, and High Schools). Hohlfeld et al. employed the Levels of Digital Divide in Schools framework, which specifies digital divide layers in K-12 schools. Hohlfeld et al. concluded that Florida is making gains in decreasing the digital divide gap. However, there is room for growth in how ICTs are leveraged for learning in Florida schools. Study results showed that students of low SES used software more frequently for skill and drill practice compared to high SES peers who used software more frequently for communicating and creating (Hohlfeld et al., 2017). Future studies in the state of Florida include a policy type analysis using the same data leveraging a regression discontinuity analysis which would enable researchers to explore educational policy decision making (Hohlfeld et al., 2017).

Backes and Cowan (2019) conducted comparative analysis research to examine the extent to which SES affects the digital divide related to students' home use of computers for learning, and Internet literacy. The authors analyzed 2009 Programme for International Student Assessment data collected from 15-year-old students from 55 individual countries. The study examined the association between variables noted at the country-level including family SES, students' home use of ICT for learning, and Internet literacy, associated with the digital divide. The study concluded that a country's national level income is a formidable predictor of the digital divide among 15-year-old students, and that targeted investments in education focused on increasing access to digital learning for all students may decrease digital inequality. Future studies could explore potential local and national level investments that may decrease the digital divide.

Tan et al. (2020) performed a Markov chain Monte Carlo multiple imputation, hierarchical linear modeling, and latent class analysis study to examine the impacts of the digital divide on achievement. The study included a sample size of 38,158 Confucian heritage cultures students from 1030 schools participating in Program for International Student Assessment. The authors examined the impact of the digital divide on mathematics achievement of students of low SES. The study employed the hierarchical framework of ICT use. It was concluded that home ICT use benefited mathematics achievement. Future studies could seek to examine the processes of how ICTs benefit achievement and explore the ways in which students lacking access to meaningful ICT use are disadvantaged.

Critique of the Literature

Current studies have examined issues of the digital divide as it pertains to economic impacts, societal impacts, quality of life impacts, and educational impacts (Pérez-Castro et al., 2021; Rogers, 2016; van Deursen & van Dijk, 2019). Current studies on the educational impacts of the digital divide include ICT integration and access, and student achievement (Hohlfeld et al., 2017; Powers et al., 2020). Current studies have also identified the need for future studies to provide a better understanding of the impacts of attempts to address learning and achievement in the digital divide in schools (Hohlfeld et al., 2017; Powers et al., 2020). The identified need for future studies on this topic will be addressed by this study.

Student achievement is an issue that still needs to be understood as defined in the problem space in current literature leading to the creation of the topic and problem statement for the study. Agasisti et al. (2020) noted the need for future research to examine the relationship between ICTs and academic achievement for students younger than age 15 in education systems such as the United States. Future research should focus on the causal effect of computer use on achievement in other subjects than mathematics and science (Karlsson, 2020). In addition, the effects of computer usage on the relationship between student SES and achievement needs to be further analyzed, according to Chiao and Chiu (2018). Based on this information, this study, which addressed the problem space of the digital divide, is an important endeavor.

The need for further understanding of the impacts of the digital divide on student achievement differences leads to the creation of the topic for this research and problem statement for the study. The problem statement for this study was that it was not known to what extent differences existed in eighth-grade ELA and mathematics summative assessment achievement outcomes for students of low SES based on years of participation in a Washington school district's one-to-one laptop program. The review of the literature section addresses the educational need for this research and concludes with a summary of the literature.

Computers and Education

Computers are nearly everywhere in education, impacting both teaching and learning. Computers and education will be explored in this section to provide background information specific to the overall dissertation topic of achievement differences based on years of participation in a one-to-one laptop program. Computers influence our feelings, thinking, communication, actions, and the ways in which we access and share knowledge (Chen & Bonanno, 2020). Rapid advancements in technology influence how instruction is delivered, learning is facilitated, and knowledge is processed (Chen & Bonanno, 2020). Computer hardware and software are more capable than ever, providing individualized content delivery through just in time data collection and analysis, providing immediate feedback to students. As a result, students experience customized learning experiences while computers seamlessly collect data useful for informing instructional next steps.

The power of computers in education is clear. Introduction of the Internet has led to an increased drive by educational institutions to provide computers to all high school students (Hanimoglu, 2018). Computers have changed the way teachers teach, and students engage with peers in learning (Hanimoglu, 2018). Teachers are increasingly interested in knowing best practice strategies for computer use in face-to-face classroom settings as well as with online learning (Chen & Bonanno, 2020). Computers impact both teaching and learning in and outside classroom walls.

The presence of computers in education has seen unprecedented growth. In 2020, the global pandemic, COVID-19, caused a sudden shift for classrooms from face-to-face instruction to fully online e-learning (Shah & Shaker, 2020). E-learning takes place when there is full physical separation of teacher and students in a virtual online classroom setting (Shah & Shaker, 2020). Many school districts were faced with the sudden requirement to provide computers to students so that crisis learning could continue when COVID-19 shelter in place mandates happened (Shah & Shaker, 2020). This brought to light discussions on equity and oppression related to ICT access as learning suddenly required that students have a computer (Shah & Shaker, 2020). Computers are everywhere today, and education is no exception (Chen & Bonanno, 2020). To better understand how far the topic of computers in education has come, a historical understanding is important.

Historical Perspective

Computer technology and use has evolved rapidly since the initial use of computers in schools. From a historical perspective, computers in education have experienced a meteoric evolution in form, function, and use (Anil et al., 2018). First utilized in schools in the 1980s (Domine, 2009; Fraillon et al., 2019), computers were mostly utilized by teachers for grading, and assignment and assessment creation (Domine, 2009). In the beginning, computers were a significant, unproven, and unfamiliar district expense (Domine, 2009). Most schools reserved devices for teacher use only (Domine, 2009). In addition, professional development was not common, leaving teachers to wonder how to integrate computers as tools for student learning (Domine, 2009). As the power of computers was realized throughout the 1980s changes emerged for schools and the workplace.

Computer use continued to gain momentum in the workplace, and slowly in schools as well. In 1983, the microcomputer was deemed machine of the year, placing tremendous pressure on educators by an eager public to embrace the use of computers in schools (Birman & Ginsburg, 1983). In the early 1990s, computers began to surface in singles, or small clusters in libraries and classrooms for student use with an initial focus on word processing (Domine, 2009). Computer use in schools continued to evolve in the 1990s from word processing and cutting and pasting text (Domine, 2009), to include basic skills drill and practice activities (Tucker, 1983). By the mid-1990s, computer labs became more common in schools and libraries (Tucker, 1983). Interest in computer use in schools was gaining momentum in the early 2000s, and school leaders began to consider what the potential benefits of regular computer use might be for students pursuing academic goals. During this time, school leaders began to expand their thinking about the potential power computer use held for students.

Parents experiencing the power of computers in the workplace wanted their children prepared for employment after graduation. In the 1980s, parents with jobs that involved computers were especially vocal about the need for students to graduate ready for the workforce (Tucker, 1983). Pressure on district leaders to embrace computer integration gave cause for pause as district leaders considered the big picture. Challenges to be addressed by school district leaders in the early 1980s included the significant investment in computers, new computer-based curriculum, and professional development (Tucker, 1983). Research was needed to help inform district leaders about the need to prepare graduates with computer skills for general employment (Birman & Ginsburg, 1983). In the 1980s, pedagogy and instruction questions surfaced about potential computer aptitude differences between male and female students based on mathematical ability (Hearne & Lasley, 1985). Additional challenges in the mid-eighties included the lack of qualified computer-literate teachers who were expected to facilitate computer-based instruction (Poirot et al., 1988). Despite challenges, school district leaders continued to pursue and explore the many opportunities that computers made available to students.

Through the 1980s, there continued to be challenges for school administrators in finding teachers qualified in the use of computers for education. Schools were faced with the reality that qualified computer teachers were not readily available in the pool of new teacher graduates (Poirot et al., 1988). Teacher retraining programs were created, and in

1985, the Teacher Retraining Taskforce was formed (Poirot et al., 1988). The role of the Taskforce was to study computer science retraining programs and make recommendations for the future of training development (Poirot et al., 1988). Poirot et al. (1988) opined the need for teacher retraining was a national problem. Despite the shortage in qualified educators by the late 1980s, the demand for computers in schools continued (Poirot et al., 1988). During this time period, a discrepancy existed between the availability of computer literate teachers and the need for continued expansion of the use of computers in schools. Hiring managers from industry were calling for a need to close this gap and for schools to provide graduates with computer skills.

By 1988, computer use in K-12 schools was widespread across all levels. Computer use ranged from students and teachers to administrators (Poirot et al., 1988). Reid and Taylor (1989) noted school administrators' computer use evolved from word-processing, occasional budget tasks to data mining for data analysis, and creation of mathematical models to support decision-making. Computer use in schools continued to evolve throughout the 1980s (Reid & Taylor, 1989). As administrators leveraged computers for data mining and decision making in the late 1980s, teachers used computers for lesson planning and instruction, and student use focused on computers for word processing, skill practice, data entry, mathematics, and computer science classes (Reid & Taylor, 1989). By the end of the 1980s, a need for more computers and the idea that each student may benefit from access to their own personal computer was evident (Reid & Taylor, 1989). Expanding computer use propelled the vision of computers in education from word processing to a key tool for learning.

During the early 1990s, the concept of increased access to computers for students became increasingly important. Apple embraced this concept and launched its Apple

Classrooms of Tomorrow (ACOT) program. From 1985 to 1995, ACOT research focused on five school sites at which they provided a computer for use at school for every student and teacher, and a computer for use at home for every student and teacher (Baker et al., 1993). This was the beginning of the concept of one-to-one computer programs. According to Lamb and Weiner (2018), one-to-one programs are those in which each individual student is provided with a technology device, for the purposes of education. The goal of ACOT was to determine the impacts of routine computer use on teaching and learning (Baker et al., 1993). After 2 years, researchers concluded that student engagement with computers increased with regular use, and that teachers were capable of instructing students in learning with computers (Dwyer, 1994). The positive outcome fueled Apple's desire for further research (Dwyer, 1994). Apple continued at the forefront of computers in education over the course of the 1980s and into the 1990s.

In 1987, Apple launched its second phase of one-to-one research. Apple Classrooms of Tomorrow—Today (ACOT2) spanned from 1987 to 1990 (Apple, 2008). ACOT2 was a similar one-to-one program model to ACOT, serving as a collaborative effort with the education community (Apple, 2008). The difference was the research goal. ACOT2 sought to determine which design principles were required for the modern 21st-century high school (Apple, 2008). The key differentiating factor in ACOT2 is that it focused on relationships between students, teachers, and curriculum (Apple, 2008). Apple had learned from its previous one-to-one ACOT model and evolved its mission to help high schools create learning environments that encouraged students to stay in school (Apple, 2008). ACOT and ACOT2 were the first of their kind one-to-one computer programs initiated in public schools (Apple, 2008). One-to-one computer programs in schools today are based on the initial research of ACOT and ACOT2.

Legislation

By the early 1990s, the concept of computers in education had gained enough momentum to appear on the radar of legislators. The landscape of education had changed dramatically with the introduction of the personal computer (Apple, 2008). Preparing high school graduates for the technology-rich world of work presented a new challenge for districts who needed direction and guidance from the government for how to prepare students for this new world (U.S. Department of Labor, 1991). Before computers, all high school graduates needed was a solid work ethic, strong back, and a high school diploma (U.S. Department of Labor, 1991). With evolving requirements for technology skills by employers, districts needed governmental guidance regarding new curriculum and course offerings (U.S. Department of Labor, 1991). The importance of technology integration in schools was recognized by leaders in the U.S. Department of Labor.

In 1990, the U.S. Department of Labor created the Secretary's Commission on Achieving Necessary Skills (SCANS). The goal of SCANS was to define specific entry-level job skills required by high school graduates (U.S. Department of Labor, 1991). SCANS surfaced the need for standards and graduation requirements that aligned with the foundational technology skills and competencies required in the workplace (Whetzel, 1992). SCANS specifically addressed the importance of technology utilization skills that schools needed to include in curriculum and course offerings (U.S. Department of Labor, 1991). SCANS was the impetus for creating a law in support of academic reform.

The next major piece of education legislation was The Goals 2000: Educate America Act, which became law in 1994 (Office of Elementary and Secondary Education, 1998). Goals 2000 centered on state-level support for academic standards reform (Office of Elementary and Secondary Education, 1998). Goals 2000 grants were to be utilized by districts in part to improve the skills and content knowledge of staff, update curriculum, and to expand the use of instructional technology (Office of Elementary and Secondary Education, 1998). Many districts used Goals 2000 to generate a data driven needs assessment which resulted in educational technology surfacing as the needed area of focus (Office of Elementary and Secondary Education, 1998). Goals 2000 emphasized standards reform including academic content area and performance standards (Office of Elementary and Secondary Education, 1998). Also included were accountability measures, assessment, achievement, teacher preparation, stakeholder involvement, and coordinated change (Office of Elementary and Secondary Education, 1998). Goals 2000 created state-level support for standards reform, which resulted in the need for accountability measures.

Once the U.S. government determined the need for updated standards to help graduates secure gainful employment, the next step was to determine accountability measures (Husband & Hunt, 2015). The No Child Left Behind was signed into law by Congress in 2001 and focused on the need for states to develop specific education standards (Husband & Hunt, 2015). The call for educational reform and NCLB was driven in large part, by the computer (Husband & Hunt, 2015). Technology related education reform is still evolving as both technology and student needs change.

A subsection of No Child Left Behind, known as the Enhancing Education Through Technology Act of 2001, went beyond standards, including direction for improving school achievement through the use of technology. The Enhancing Education Through Technology Act of 2001 provided special funding at the state and local level for the goal of implementing a K-12 system designed to leverage technology to improve student achievement. Such programs should involve public-private partnerships to increase access to technology. Funding was allocated for infrastructure, networks, technology maintenance, professional development, reaching learners in isolated regions, measuring achievement, increasing family communication and engagement, and ensuring every student crosses the digital divide. By the early 2000s, it was clear that the concept and use of computers in education was expanding across all levels.

On December 10, 2015, the Every Student Succeeds Act was signed into law to address the unrealistic expectations for accountability placed on states by No Child Left Behind (Adler-Greene, 2019; Heise, 2017). Like No Child Left Behind, the newly enacted Every Student Succeeds Act also included technology but with greater specificity for funding. Section 4109, Activities to Support the Effective Use of Technology, calls out appropriate use of funds as designated to improve: the use of technology, achievement, academic growth, and student digital literacy in schools. Specific examples include funding to support computerized adaptive testing, personalized learning, student achievement, professional development, infrastructure, and devices. To address the need for computer literacy by all students, the Every Student Succeeds Act provides states with funding to support programs such as computer integration models designed to personalize learning and increase achievement. Much has been learned about the importance of computer integration in schools since personal computers first appeared in schools in the 1980s.

Computer Lab

Computer lab integration models are those in which a separate room is equipped with a classroom set of computers (Clemons, 2006). Schools with computer labs can provide scheduled one-to-one student access to computers in a lab setting (Reese, 1998). In many cases, a technology specific teacher is assigned the role of running and managing the computer lab (Nayar & Barker, 2014). Computer labs provide teachers with access to a full class set of computers on an as needed basis (Reese, 1998).

In larger schools, scheduling computer lab time can be challenging with classes typically only able to schedule one 1- to 2-hour session in the computer lab per week (Nayar & Barker, 2014). Most computer lab integration models are equipped with 30-40 computers and provide seating for 35 to 45 students at a time (Nayar & Barker, 2014). Teachers reserve time in the computer lab for students to work on projects requiring specialized software that may not be available on student or classroom computers (Reese, 1998). For example, computer labs may have computers loaded with specialized software for music composition (Reese, 1998), Computer-aided design, robotics, publishing, and video editing (Clemons, 2006). Computer labs are a cost-effective way for school districts to provide the cutting-edge technology and software required for specialized programs to multiple students. Additionally, schools in less affluent countries often rely on government provided computer labs as they may not have the infrastructure to provide connectivity in more than one location within a school (Qadir & Hameed, 2018). However, cost is not the only parameter to consider.

While cost effective, the computer lab integration model is not optimal for student interaction (Nussbaum et al., 2015). The best location for computer integration has been an ongoing topic of discussion with both classroom and computer labs surfacing as the most desirable (Nussbaum et al. 2015). Drawbacks include that computer labs are less conducive to collaboration, discussions, group work, and peer discourse (Nussbaum et al., 2015). Scheduling can also prove to be a challenge when multiple teachers need the lab on the same day (Reese, 1998). The computer lab integration model is clearly an intermediate stage on the trajectory to computers being consistently available in all classrooms (Nayar & Barker, 2014). For districts not ready for full scale one-to-one adoption, computer labs have the potential to provide high-quality learning experiences in curriculum-required learning (Nayar & Barker, 2014). A variation on the computer lab model is one that affords students access to movable workstations.

Mobile Computer Lab

The mobile computer laboratory (MCL) integration model is made possible when schools purchase cabinets containing student laptops that come pre-loaded with grade level or subject specific productivity tools, Internet, and intranet capabilities. The MCL can be wheeled between classrooms as needed. The total number of laptops in each cabinet depends on the number of students per class, so that each student in a grade level has access to a laptop. The MCL integration model typically includes one laptop per teacher. Teacher laptops come preloaded with software allowing the teacher to manage the classroom's digital workspace, and communicate with students. MCLs give teachers instructional flexibility coupled with the security of district managed devices.

Benefits to the MCL model include flexible workgroups because access to individual laptops as movable workstations encourage spontaneous collaboration. Additional advantages of the MCL model include the ability for students to share work across computers with teachers and classmates for just in time feedback and peer-critiques. MCLs offer privacy and security as all devices are owned and maintained by the school district. The benefit of additional classroom space being made available as the laptops can be wheeled wherever needed instead of stationary labs in one permanent location is a space saving advantage of the MCL model. While space may be saved, the structural integrity of devices may suffer.

However, the MCL model is not without challenges. Laptops may be dropped by students during retrieval from carts, resulting in broken keys or further damage. Students do not always plug the laptop in when returning it to the cart, resulting in dead batteries for the next user. Additionally, student desktop spaces are small, making falls from bumped desks likely. The damage frequently goes unreported by students and is unnoticed by staff until the next time the laptop is used. When teachers have critical lessons planned, finding broken laptops at the last minute can result in reluctance to count on the MCL for future use. When laptops are stored on mobile carts, it can be cumbersome to update software, maintain proper working order, and disinfect. The challenges of restricted access to the shared resource of a lab computer integration model (Nayar & Barker, 2014), prompts many school districts concerned with costs to opt for the BYOD computer integration model (Semenikhina et al., 2019). BYOD offers significant benefit to school district finances but may generate equity challenges.

Bring Your Own Device

BYOD is cost effective and quick to implement. The BYOD computer integration model functions by students bringing personal computers and tablets from home for educational use at school (McLean, 2016). Computer cost is a major factor for most school districts on limited budgets (McLean, 2016). Educational institutions are experimenting with ways to integrate computers to improve student achievement while reducing costs (Kozakowski, 2019). BYOD addresses the financial burden on schools when there is a need for more computers when numbers are limited (McLean, 2016). The BYOD model is unique in relieving financial burdens experienced by school districts providing computers that must keep pace with constant change (McLean, 2016). With the responsibility for computer purchase and maintenance on the individual, rather than the district, the BYOD model is an attractive choice for many schools (Hopkins et al., 2017;

McLean, 2016). A BYOD computer integration model is relatively turnkey, requiring minimal maintenance on the part of the school district (Hopkins et al., 2017). Therefore, BYOD has increased in popularity with budget conscious school districts.

BYOD schools treat computers as a school supply. In a BYOD model, families provide a computer for their child's use at school in a similar way to basic school supplies (McLean, 2016). This is a cost-effective choice for schools (Adane, 2020). While cost is reduced with the BYOD model from a device perspective, schools are still responsible for providing infrastructure and Internet access (Adane, 2020; McLean, 2016). Instituting BYOD is often the quickest path for schools in becoming a fully digital learning space (McLean, 2016). Schools implementing BYOD programs benefit from computer-based testing which improves the management of testing procedures in large classes. Many school districts have transitioned away from paper-based assessments to computer-based assessments.

Hopkins et al. (2017) conducted a study to verify whether, and to what extent, computer-based assessment can be considered as a suitable alternative to paper-based assessments in a BYOD environment. The study examined students' test performance, perceptions and preferences towards computer-based testing for end of course examinations within a BYOD model. There were 606 students participating in the study with 443 taking the computer-based test and 163 taking the test on paper. Study findings showed that students taking the computer-based test demonstrated better performance, and that a positive relationship existed between the students' perceived level of self-efficacy and their propensity to adopt digital tests. Future research is recommended to investigate whether less prepared students, either males or females, or those with a lower self-efficacy level would be more likely to take computer-based tests using personal devices. While the BYOD model offers benefits to students and districts, there are challenges that cannot be overlooked.

Challenges exist with the BYOD model that are important to be aware of prior to adoption. One challenge districts face is addressing BYOD vulnerability (Adane, 2020). Vulnerability comes in the form of classroom and district level security and privacy breaches due to unknown devices accessing district Internet (Adane, 2020). As BYOD continues to increase in popularity, behavioral and cyber security issues may follow (Chou et al., 2017). Behavioral concerns include the potential for students to access inappropriate content or websites (Chou et al., 2017). Security threats may occur when students bring computers from home that may pose threats to school network systems (Chou et al., 2017). Additionally, concerns with the quality of devices students bring from home may contribute to classroom social and learning inequalities (Chou et al., 2017) perpetuating the digital divide. Quality of devices and student safety and security are important components of any computer integration model.

Themes present in BYOD research that are relevant to the dissertation topic include student achievement, and digital divide. There is a need for this study to examine the differences in student achievement when all students are provided with the same make and model of computer as in a one-to-one program, ensuring equity for all students. McLean (2016) noted that the BYOD model of computer integration may contribute to inequity despite schools purchasing loaner devices for those students without access to a personal laptop. Devices may look and perform differently such as devices coming to school with students from affluent families, or devices that come to school with students of low SES.

One-to-One

In the latter part of the 1990s, one-to one computer initiatives began to emerge in K-12 schools (Vu et al., 2019). According to Lamb and Weiner (2018) and Cho (2017), one-to-one programs are those in which each individual student is provided with a technology device, for the purposes of education. Bixler (2019) noted that one-to-one programs provide devices to individual students for 24/7 use. One-to-one programs provide unique benefits including the ability to individualize instruction and learning experiences, device portability, affordability, and increased peer collaboration (Bixler, 2019). Launching in the 1990s, one-to-one programming continues its momentum as a popular model of technology integration.

Maine was the first state to embrace one-to-one programming, leading the first statewide one-to-one computer program in 2002 (Vu et al., 2019). With steady increases in ICT purchases by school districts across the United States since 2002, one-to-one programs in K-12 schools continue to expand (Vu et al., 2019). Between 2013 and 2014, U.S. schools purchased over 23 million ICTs for use in one-to-one programs (Vu et al., 2019). Mixed research findings on the rapid investment in one-to-one programs on educational outcomes are present in recent literature (Vu et al., 2019). Therefore, the question of return on investment remains unanswered according to the literature.

There is an ongoing debate between supporters of one-to-one programs in schools, and those who argue that the costly investments are not backed by evidence of student achievement (Bass, 2021). Studies citing small, no, or a negative impact on student achievement for one-to-one computer programs include research by Bixler (2019), Hull and Duch (2019), and Yanguas (2020). In a recent comparison study on a one-to-one iPad program conducted in a private school district, hierarchical linear modeling was used to examine student achievement at three middle schools (Bixler, 2019). Achievement test scores from all middle school students in mathematics and science were collected and analyzed (Bixler, 2019). The study measured student achievement over the course of two years (Bixler, 2019). Study results provided that the one-to-one iPad program had no significant effect on middle school student achievement in either mathematics or science (Bixler, 2019).

Both the Hull and Duch (2019) and Yanguas (2020) studies used a quasi-experimental methodology. Hull and Duch utilized data from the North Carolina Education Research Data Center, focusing on achievement test scores from the End of Grade files for students in Grades 4 to 8. Hull and Duch reported one-to-one laptop programs had small effects on mathematics test scores with effects only appearing after a few years (Hull & Duch, 2019). Short-term student achievement impacts of the program were statistically insignificant, and mathematics scores improved by 0.13 standard deviations in the medium term (Hull & Duch, 2019). Additional research focusing on student achievement was conducted by Yanguas (2020) in Uruguay.

In 2007, Plan Ceibal in Uruguay implemented a one-to-one laptop program with all public elementary and middle school students across the country (Yanguas, 2020). Research in Uruguay by Yanguas (2020) was the first research addressing the long-term effects of a one-to-one program on the country level scale. To identify the causal effect of the one-to-one intervention, program participation was linked to participant’s early-adult educational outcomes (Yanguas, 2020). Survey and administrative data were collected and analyzed from the National Institute of Statistics and Uruguay's public university system (Yanguas, 2020). Using a regression discontinuity in time study design, Yanguas found no favorable effect of one-to-one programs on test scores with results suggesting decreases in educational attainment when students participated in one-to-one laptop programs. Current research has yet to make a definitive declaration on the impacts of one-to-one programs on student achievement with research findings both rejecting and supporting one-to-one programs.

Study results finding favorable effects of one-to-one programs on student achievement are shared by Bass (2021) and Vu et al. (2019). In a study of principal and educational technology directors from 15 rural public K-12 schools in a mid-western state, participants responded to interview questions to determine the impact of one-to-one programs on teaching and learning performance (Vu et al., 2019). Ten of the 15 total participants reported positive changes in both teacher and student performance (Vu et al., 2019). Various reasons for one-to-one program support were shared by respondents. One participant specifically noted a positive trend in standardized test scores, while others noted increased engagement and participation especially from non-native English speakers (Vu et al., 2019). Overall, participant responses to interview questions to determine the impact of one-to-one programs on teaching and learning performance were favorable, and they reported feeling confident about the investment required to implement the one-to-one program (Vu et al., 2019). Additional research reporting the favorable effects of technology on student achievement are reported by Bass (2021).

A recent study by Bass (2021) was designed to provide causal estimates of the impacts of districts' California Education Technology K-12 Voucher Program investments in one-to-one programs on student achievement. California schools are eligible for the voucher program when serving 40% of a student population qualifying for free or reduced-price meals (Bass, 2021). The author noted increases in both mathematics and English test scores for elementary and middle school students (Bass, 2021).

Additionally, one third to nearly one half of a standard deviation point increase in English test scores was reported for middle school and students of low SES (Bass, 2021). Study findings conclude that district technology investments on computers, and software for productivity and reading/English, does improve student achievement, especially for students of low SES (Bass, 2021). Despite favorable results in some studies, varying perspectives remain.

Summary of Computers in Education and Achievement

Computers in Education

This section of the literature review included perspectives on the topic of computers in education. When computers first appeared in schools, they were costly, large, and difficult to use (Meyer, 2017), making widespread computer integration a challenge. As a result, most schools had only one, or a small bank of computers available for student use (Meyer, 2017). Over time, costs and device sizes have decreased (Powers et al., 2020), expanding the options for computer integration models. Understanding different types of computer integration models is relative to the overall dissertation topic, which focuses on the one-to-one laptop computer model as understanding the ways in which computers are made available to students in schools provides background understanding for the dissertation topic. Four computer integration models prevalent in schools today include computer labs, MCL, BYOD, and one-to-one laptops.

Examining various models of computer lab integration brings to light benefits and drawbacks for school districts. Benefits include a cost-effective way to provide the latest in computers and software to all students (Chou et al., 2017). Drawbacks to the computer lab model include scheduling challenges and decreased student collaboration (Nussbaum et al., 2015). Further consideration of the various computer integration models examined in this section follows.

The MCL model was examined in the literature. Advantages for school districts apparent in the literature include the ability for students and teachers to share work seamlessly across a secure intranet (Chou et al. 2017). Also noted was a greater opportunity for spontaneous collaboration in flexible workgroups when all students have the same ICT device with the same software. Challenges of the MCL model include device management, from regular disinfecting to cumbersome software updates required on each individual device. Consideration of the advantages and disadvantages of the MCL model were followed by a review of the BYOD model.

The BYOD model was then considered as a cost effective and expedient way for schools to be a fully digital learning space. Current literature noted that challenges of the model must be addressed prior to adoption. Concerns with the BYOD model included student behavior, privacy and security, and potential for a deepening of the digital divide (Chou et al., 2017). The BYOD model was examined and followed by consideration of one-to-one computer integration models.

The one-to-one computer integration model was reviewed in the research as it is a popular choice for schools as evidenced in the growing number of ICT purchases by schools each year (Vu et al., 2019). Benefits evident in current literature unique to the one-to-one model include the ability for instructors to individualize instruction and learning experiences, and 24/7 student access (Bixler, 2019). The concern expressed in current literature is that one-to-one computer integration models are costly, and not fully supported by clear evidence of increased student achievement in the literature (Bass, 2021). Through the examination of computer integration models, themes emerged.

Themes relative to the research topic of the achievement differences based on years of participation in a one-to-one laptop program that emerged from the literature include benefits and challenges of current computer integration models such as computer labs, BYOD, MCL, and one-to-one laptops. The themes that emerged from research of the literature on computers in education are relevant to the dissertation topic of achievement differences based on years of participation in a one-to-one laptop program. Examining varying computer integration models will contribute to the literature on one-to-one computer integration and student achievement.

The themes of benefits and challenges of current computer integration models are relevant to the causal-comparative methodology and two instruments for this study. The causal-comparative methodology compares student achievement on the SBAC summative ELA and mathematics eighth-grade tests, measuring student academic progress using scaled scores. The themes are relevant to the dissertation topic as one-to-one integration is the specific computer integration model analyzed in this study.

Reasoning for the need for this study was articulated by Chou et al. (2017) and Vu et al. (2019). The researchers stated that future research should consider another type of technology integration to determine if study outcomes are specific to the MCL model of computer integration analyzed in Chou et al.'s study. Vu et al. noted there is a need for future research on the impacts of one-to-one programs on student achievement on summative tests. Deeper examination of computers and achievement follows.

Computers and Achievement

The current study examined differences in eighth-grade students' ELA and mathematics achievement based on years of participation in a Washington school district's one-to-one laptop program. Therefore, there is a need to discuss student achievement and one-to-one laptop programs. According to Agasisti et al. (2020), there is an urgent need to discuss the effects computers have on improving student achievement. Since the 1980s, the debate over whether computers have positive effects on test scores and graduation rates has been active (Agasisti et al., 2020). The value computers bring to the classroom is rarely challenged (Mora et al., 2018). However, the question of return on investment remains as in the economics literature specifically, there is no consensus about the potential link between computers and achievement (Mora et al., 2018). This may give school districts cause for pause when considering increases in technology spending.

Increasing spending on computers in educational settings may increase equity across socioeconomic lines (Scherer & Siddiq, 2019) but may not increase achievement (Mora et al., 2018). Understanding the potential impacts of computers on achievement is relative to the overall dissertation topic as current research on computers and achievement is pertinent to the dissertation topic of achievement differences based on years of participation in a one-to-one laptop program. Current literature provides diverse perspectives and study results specific to computers and achievement (Agasisti et al., 2020; Hazlett et al., 2019; Kert et al., 2019; Mora et al., 2018; Nkemakolam et al., 2018; Robinson et al., 2018; Vu et al., 2019; Weber & Becker, 2019).

Increases in Student Achievement. Recent research by Weber and Becker (2019) on the topic of computers and achievement was analyzed. The authors conducted a quantitative study using descriptive statistics with a sample size of 154,539 high school student respondents in 7,064 schools in 25 countries (Weber & Becker, 2019). The study examined the association between parental cultural capital and students' Internet usage for school-related purposes (Weber & Becker, 2019). The authors concluded that students with higher SES, educated parents, and more books at home tend to use the Internet more often for school-related tasks than their low SES peers (Weber & Becker, 2019). This pattern was similar for school-related browsing and sharing Internet activities (Weber & Becker, 2019). Future study recommendations included the need for studies over time to investigate whether use of ICTs for school-related activities is related to higher educational achievement (Weber & Becker, 2019). This research helps substantiate the focus of this study on students of low SES.

Vu et al. (2019) performed a qualitative study with a sample size of 15 schools, examining how one-to-one initiatives were conducted in rural public K-12 educational settings in a mid-western state. The study concluded that there is a need for future research on computers and achievement. Vu et al. reported that when schools decided to initiate one-to-one initiatives, decisions were often made by limited committees and cost was frequently the committees' major consideration. None of the schools in the study evaluated or had plans to evaluate students' academic performances on standardized tests relative to the program, or the impact of their one-to-one initiative on any aspect of learning (Vu et al., 2019). Future study on this topic was recommended as none of the schools in this research project conducted a formal evaluation of one-to-one computer impacts on learning (Vu et al., 2019). Kert et al. (2019) also published research on the impacts of computers on student achievement.

A study related to the topic of computers and achievement was conducted by Kert et al. (2019). The study included both quantitative and qualitative measures through a sequential explanatory method approach (Kert et al., 2019). The study focused on teachers' and students' perceptions of academic achievement (Kert et al., 2019). Some schools provided both a computer lab and Internet access, and others were lacking equal access to technology opportunities (Kert et al., 2019). There were 162 students between

11 and 12 years old included in the quantitative portion of the study, and 101 students participated in the qualitative portion (Kert et al., 2019). Findings showed that the instructional materials and activities developed within the scope of the study, positively affected the achievement of students aged 10 and 12 years old (Kert et al., 2019). Future research was recommended to further contribute to the body of research on computers and achievement in schools with equitable technology access (Kert et al., 2019).

Research focused on computers and achievement was undertaken by Nkemakolam et al. (2018). The authors performed a quasi-experimental research design study, with a non-equivalent control group design (Nkemakolam et al., 2018). The sample consisted of 78 students, which was made up of 38 in the experimental group (18 males and 20 females), with a control group of 40 students: 16 males and 24 females (Nkemakolam et al., 2018). Participants were drawn from two coeducational secondary schools in Awka Education zone of Anambra State (Nkemakolam et al., 2018). The study was designed to examine the effects of computer simulation on the academic achievement of students (Nkemakolam et al., 2018). No theoretical framework was identified (Nkemakolam et al., 2018). The study concluded that computer simulation was more effective in enhancing students' achievement (Nkemakolam et al., 2018). Future study recommendations include replicating the study using private and public schools to better generalize computers and achievement data (Nkemakolam et al., 2018). Additionally, research on computers and achievement was conducted by Robinson et al. (2018).

Robinson et al. (2018) performed a quantitative research study on computers and achievement with multilevel random-effects and fixed-effects regression models applied to survey data. The study included a sample size of 1,051 high school seniors, predominantly of low SES, in California (Robinson et al., 2018). The study examined the effects of digital inequality in conjunction with curricular tracking on student achievement (Robinson et al., 2018). The study employed the following theoretical frameworks: academically useful computing index, leisure computing index, smartphone usage intensity index (Robinson et al., 2018). The study concluded that achievement is positively correlated with both duration of computer access and computer usage intensity (Robinson et al., 2018). Future studies could seek to identify connections between academic and nonacademic computer and achievement outcomes (Robinson et al., 2018). Additional research examined computer usage and student achievement.

Decreases in Student Achievement. Alternatively, Agasisti et al. (2020) conducted qualitative computer and achievement research utilizing data from the Organization for Economic Cooperation and Development's Program for International Student Assessment. The authors sought to determine to what extent there was an association between the way in which 15-year-old students utilized ICT at home for school-related tasks, and achievement based on test scores in the areas of reading, mathematics, and science (Agasisti et al., 2020). The sample included 2012 assessment scores from Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain and Sweden (Agasisti et al., 2020). The study employed Propensity Score Matching and produced evidence that for 15-year-old students in most countries there is a negative association between computers and achievement (Agasisti et al., 2020). Specifically, ICT use for homework was associated with lower test scores in reading, mathematics and science (Agasisti et al., 2020). The authors noted that protocols for the correct use of ICTs at home should be in place to decrease the likelihood of ICT misuse by students. Agasisti et al. called for future research on computers and achievement in the United States, specifically, to corroborate the external validity of their European study results.

A recent study to determine the impact of E-Rate funding on computers and achievement was done by Hazlett et al. (2019). The data were gleaned from 374 public high schools across 119 school districts in North Carolina (Hazlett et al., 2019). Scholastic Aptitude Test score data from 2000 to 2013 was analyzed (Hazlett et al., 2019). Study results suggested no association between E-Rate funding, which increased the student to ICT ratio, and any improvement in student standardized test performance (Hazlett et al., 2019). The authors suggested that future research on the achievement impacts of increased ICT per student ratio analyze metrics other than standardized assessment scores (Hazlett et al., 2019). Research focusing on the achievement of students on standardized testing using computers was conducted by Mora et al. (2018).

Mora et al. (2018) evaluated the impact of the Catalan government's one-to-one laptop program, known as eduCAT, on 10th-grade student achievement. Test scores from 175,493 students in Catalan, Spanish, English, and mathematics were obtained between 2009 and 2016 for analysis (Mora et al., 2018). Empirical results from all years reported a negative impact on student achievement in all testing subject areas (Mora et al., 2018). eduCAT school test scores decreased by 0.20-0.22 standardized points for all students, with a stronger negative effect seen in male students' scores compared to female students' scores (Mora et al., 2018). Overall, students from eduCAT participating schools scored an average of three standardized points less than non eduCAT schools in the subject areas of Catalan, Spanish, English and mathematics (Mora et al., 2018). The authors noted that while their study results infer causality between computers and poor achievement, study results do not provide information as to why computers do not improve student achievement (Mora et al., 2018). Mora et al. posited that eduCAT schools may not have provided software relative to testing areas, and teachers may not have received professional development on how to use computers for instruction. Additionally, the authors shared that the study was unable to account for parental support and monitoring levels at home when computers were in use, and it is also possible that traditional methods of instruction were replaced solely by methods based on the new technology (Mora et al., 2018). The authors made no specific recommendations on areas for future study.

Many studies note that computers may distract students and may even be harmful to learning, while others opine that computers positively impact student achievement (Coşar & Özdemir, 2020). There is no clear consensus on whether the implementation of computers in the classroom favorably or unfavorably impacts student achievement (Mora et al., 2018). A review of results from the literature reveals that empirical results remain mixed (Mora et al., 2018). In light of the impacts of the digital divide, this study will add to the literature and serve to address the identified research gap of the need for future research to measure the academic impacts of one-to-one programs on students' academic performances on standardized tests (Vu et al., 2019).

Summary

This section of the literature review provided a thorough review of current literature and themes on the topic of the digital divide present in current research. The section began with an introduction and examination of Siemens' (2005) Connectivism Theory as the theoretical foundation for this study. Connectivism Theory is a learning theory for the digital age that integrates principles from chaos, network, complexity, and self-organization theories (Siemens, 2005). This study examined the topic of achievement differences based on years of participation in a one-to-one laptop program. Therefore, Connectivism Theory, a theory relevant to learning, the digital age, and the problem space of the digital divide provided the foundation for the study.

A review of the literature surfaced the background to the problem and identification of the problem space. The problem space included that it was not known to what extent differences existed in eighth-grade ELA and mathematics summative assessment achievement outcomes for students of low SES based on years of participation in a Washington school district's one-to-one laptop program. The problem statement for the problem space was developed based on what remains to be understood as defined in the problem space of the digital divide and review of the literature. This study will inform the problem statement by providing information to school districts interested in examining their practice of achieving equity in technology integration to decrease the digital divide.

Evolutionary perspectives on the digital divide were presented. The Digital Divide section of the literature review began with research on the impacts of the digital divide as the disparity between developed and underdeveloped nations (Talaee & Noroozi, 2019). The topic of the digital divide evolved to focus on regional disparities (Rogers, 2016; Setthasuravich & Kato, 2020). Further narrowing occurred over time, to include a focus on society and then the individual (van Deursen & van Dijk, 2019; van Dijk & Hacker, 2003; Yu, 2006). Themes that emerged from the literature relative to the research topic include the evolution of the digital divide, as well as societal and educational issues related to the digital divide. Themes were examined from a focus on the broad country-wide impacts to a focus on regional and individual impacts (Rogers, 2016; Setthasuravich & Kato, 2020; Van Deursen & van Dijk, 2019; van Dijk & Hacker, 2003; Yu, 2006) to K-12 education (Hohlfeld et al., 2017).

The themes that emerged from research of the literature on the digital divide include the evolution of the digital divide and societal and educational issues related to the digital divide. Examining the topic of the digital divide will contribute to the literature on one-to-one computer integration and student achievement. Themes are relevant to the quantitative research methodology to compare achievement differences based on years of participation in a one-to-one laptop program. These themes are relevant to the selected instrumentation of the independent-samples *t* test because it served as the analysis procedure to answer each research question. Themes present in digital divide research are presented next in this chapter.

The Levels of Digital Divide in Schools conceptual framework (Hohlfeld et al., 2008) was examined. Hohlfeld et al. shared a three-level pyramid model of the Levels of Digital Divide in Schools. The pyramid structure is made up of three layers: school infrastructure, classroom, and individual student empowerment. The first layer of the Levels of Digital Divide in Schools pyramid is the foundational level for ICT use in the school. Level 1 includes school infrastructure, access to both hardware and software, Internet, and available ICT support (Hohlfeld et al., 2008). Research by Neuman et al. (2018), pertaining to a school's ability to provide resources such as infrastructure, was shared. Neuman et al. opined that a school's SES was found to have a greater deleterious effect on student achievement than individual student SES. School infrastructure solidly in place supports the ability of students to transfer from Level 1 to Level 2.

The second layer of the Levels of Digital Divide in Schools pyramid, Level 2: classroom, was examined. Level 2 includes the frequency at which students and teachers utilize technology for instruction and learning (Hohlfeld et al., 2008). Liu et al. (2017)

noted that teacher prior experience and comfort with ICTs in part determines the extent to which ICTs for learning are made available to students in class. The authors determined that teacher comfort levels and ICT integration are linked (Liu et al., 2017). Teachers must be comfortable utilizing technology for students to fully benefit from ICT access and related instruction.

The third level of the Levels of Digital Divide in Schools pyramid, Level 3: individual student, was presented. The third level includes the way in which ICTs are used to empower students as individuals (Hohlfeld et al., 2008). Students with solid ICT literacy are able to seamlessly utilize ICTs for productivity. Scherer and Siddiq (2019) conducted a meta-analysis to determine if a relationship existed between SES and students' ICT literacy skills. The authors determined that a positive and significant correlation between SES and students' ICT literacy skills exists (Scherer & Siddiq, 2019). Utilizing ICTs for productivity is a contributing factor to student empowerment.

The value of this research is that it will add to the literature on one-to-one programs and student achievement. This study analyzed differences in student achievement based on years of participation in a one-to-one laptop program. The research problem aligns with the research gap identified by Weber and Becker (2019), stating the need for future long-term research to investigate whether school related Internet connected technology use impacts student achievement. The problem statement emerged from the identification of the problem space and review of the literature.

Additional arguments for the need for the study are supported by the work of van Deursen and van Dijk (2019), who called for future research to explore investments focused on reducing the digital divide. Liu et al. (2017) noted a need for future research to examine other variables relevant to ICT integration in K-12 settings. Reviewing research on the progression of the digital divide to K-12 education provides research supported data to inform school districts on the impacts of the digital divide pertaining to K-12 education. For example, achievement differences documented in this study for students of low SES, impacted by the digital divide, may document increases or decreases in student achievement when students participate in one-to-one laptop programs. Results from this study may help to inform spending decisions on technology in K-12 schools.

Research Questions

This study had two research questions that guided the study and were aligned with the study's topic and theory. The purpose of a quantitative research question for a study is to reflect what the author wants to know about the problem for the study (McGregor, 2018). McGregor (2018) noted that the research question is a specially designed interrogative sentence that asks a question specific to the difference between variables. The purpose of quantitative research questions is to spark the process of numerical data collection to explain a specific phenomenon (Muijs, 2004).

The purpose of a hypothesis for a study is to provide a statement about the relationship between variables that can be tested (Wagner & Gillespie, 2019). The independent variable for this study involved years of participation in a one-to-one laptop program. Specifically, the years of participation utilized for this study's two groups included 1 year of participation and 3 years of participation in the target one-to-one program. The two dependent variables for this study were ELA and mathematics student achievement scores on the SBAC summative assessment. For these two variables, scaled scores were utilized. Hypotheses were written based on currently available evidence (McGregor, 2018). A hypothesis is a testable statement made about the specific parameters of a population or the functional form of the population involved (Kirk, 2013). In addition, a hypothesis is a supposition not yet verified but, if found to be true, would explain facts (McGregor, 2018). The purpose of this quantitative, causal-comparative study was to determine the extent to which a statistically significant difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES who participated in a Washington school district's one-to-one laptop program for 1 year versus 3 years. The following research questions were established to guide this applied dissertation:

1. What is the statistical difference, if any, between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated in the program for 3 years in a mid-sized, suburban school district in the state of Washington? The null hypothesis stated there is no statistically significant difference between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. The alternate hypothesis stated there is a statistically significant difference between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

2. What is the statistical difference, if any, between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low

SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington? The null hypothesis stated there is no statistically significant difference between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. The alternate hypothesis stated there is a statistically significant difference between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to-one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

Chapter 3 will focus on a discussion of the methodology. The following elements will be included: participants, instrument, and procedures. Validity and reliability, the process detailing the sample, population, sampling procedure, instruments, study design, procedures for data collection and analysis, descriptive statistics, and inferential statistical tests will also be presented.

Chapter 3: Methodology

Introduction

The purpose of this quantitative, causal-comparative study was to determine the extent to which a statistically significant difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES who participated in a Washington school district's one-to-one laptop program for 1 year versus 3 years. The research on problem space that was addressed by this study involved the digital divide. This study took place in a Washington state school district. The specific problem of interest for this study was that it was not known to what extent statistically significant differences existed in eighth-grade ELA and mathematics summative assessment achievement outcomes for students of low SES based on years of participation in a Washington school district's one-to-one laptop program. This study will address identified gaps in the current research literature (Bass, 2021; Bixler, 2019; Rizk & Davies, 2021; Vu et al., 2019; Weber & Becker, 2019). Information from this research is needed to help inform the research gap as to the extent to which student achievement based on years of participation in a one-to-one laptop program. This study may help school district decision-makers when considering the return on investment of one-to-one laptop programs and their potential impact on student achievement. This information may also be beneficial to school districts looking to address the problem space of the digital divide.

The methodology for this nonexperimental study was quantitative, and the design for the study was causal-comparative, also known as ex post facto. According to Brewer and Kubn (2010):

A causal-comparative design is a research design that seeks to find relationships

> between independent and dependent variables after an action or event has already occurred. The researcher's goal is to determine whether the independent variable affected the outcome, or dependent variable, by comparing two or more groups of individuals. There are similarities and differences between causal-comparative research, also referred to as ex post facto research, and both correlational and experimental research. (p. 125)

This study used a quantitative methodology to address the problem statement. A quantitative methodology was defined by Frey (2018) as a quantitative research method focused on empirical inquiry to understand social phenomena. Whitehead (2019) noted that the quantitative methodology is appropriate for research requiring measurement and statistical analysis of numerical data. The author also shared that quantitative research is uniquely designed to answer research questions through a planned process of describing and measuring, applying objective measurement, and attempting to determine statistically significant differences (Whitehead, 2019).

The rationale behind the decision to select a quantitative methodology is that, according to Bass (2021), few quantitative studies have examined the effect of technology investments on student achievement. The quantitative research that exists on ICTs and student achievement is both limited and provides mixed results (Bass, 2021; Vu et al., 2019; Weber & Becker, 2019). Bass (2021) also noted that current studies typically use quasi-experimental designs and are not conducted in the United States. This study sought to determine if and to what extent differences existed between groups established based on years of participation in a Washington school district's one-to-one laptop program, and student achievement in ELA and mathematics, which can only be established quantitatively. Therefore, the quantitative methodology was better suited for this research study than alternative methodologies including qualitative and mixed methods. A qualitative or mixed methods research approach would not allow for the specific analysis and measurement of variables as stated in the research questions.

This study looked for empirical data relevant to the problem space to support the knowledge that equitable access to tools for learning as in one-to-one laptop programs, is necessary for student achievement. As a result, this research will help to determine the extent to which there are differences in ELA and mathematics achievement based on years of participation in a Washington school district's one-to-one laptop program. This research addresses the need expressed by Bass (2021) for research examining student achievement.

Current research does not provide a clear answer to this study's research questions as study results on one-to-one ICT programs and student achievement are mixed. Robinson et al. (2018), in examining the effects of digital inequality on academic achievement, found a positive correlation in their quantitative research between the duration, or length of time students participated in the one-to-one program, and student achievement. In a quantitative comparative study, Bixler (2019) examined the impact of iPads in a one-to-one program on student achievement and found no statistically significant increase in the mathematics or science measures of academic progress scores of middle school students.

Because current understanding of one-to-one laptop program's impacts on student achievement is still mixed, this study sought to provide additional insights in a United States middle school setting. The quantitative methodology aligned with the research questions and hypotheses, making it the methodology of choice based on what still needs to be understood from the problem space, the problem statement, and research questions.

Applying the quantitative methodology allows for clear and unequivocal wording of the hypotheses and the testing of all variables and the differences between them (Allen, 2017; Kozleski, 2017).

The quantitative methodology was most appropriate for this nonexperimental quantitative causal-comparative study because Allen (2017) described quantitative methods as those relying on data measurements to explore questions pertaining to a sample population. This study utilized archival data measurements to explore research questions to determine if and to what extent a difference existed in the sample population of eighth-grade students' ELA and mathematics summative assessment achievement outcomes between groups. Study conditions for this study were not manipulated, and there was no random assignment because this study utilized only archival data.

This study included data from the field of education, where the quantitative methodological approach has been relied upon extensively for its objectivity (Frey, 2018). Frey (2018) shared that selecting a quantitative methodology reduces the potential for bias and subjectivity in both data collection and analyses. This study focused on one school district, and Allen (2017) noted that data discovered by quantitative methodology can often be extrapolated to fit a larger sample size. Utilization of quantitative methodology allows for the systematic comparison of responses across a large sample population in an inexpensive, timely and consistent way (Coghlan & Brydon-Miller, 2014). Moreover, the quantitative method allows the researcher to identify and test the relationships between variables (Allen, 2017). The quantitative methodology aligned with this research as the research questions sought to determine the statistical difference if any in student achievement between years of participation in a one-to-one laptop program.

A qualitative methodology was not applied to this research study. Qualitative research relies on exploration, observations, interviews, perspectives, thoughts, feelings, interpretations and beliefs rather than variables with statistically significant outcomes that are replicable in future studies (Arghode, 2012; Sarma, 2015). Data relevant to this study were archival numerical data, omitting the need for observations and/or data collection related to participant perceptions or beliefs. Additionally, Eakin and Gladstone (2020) shared that qualitative data must be interpreted which can result in misrepresentation. Since the data in this study were numerical and were measured for statistical significance, there is no data to interpret. A third methodological classification is mixed methods.

A mixed methodology was not appropriate as it does not meet the requirements for data collection as no qualitative components of data collection exist. A mixed methodology includes both quantitative and qualitative work (Gay et al., 2008), and this study was quantitative only. Mixed methods research deals with relationships between different data types from quantitative and qualitative research which can be messy (Åkerblad et al., 2020). This study did not deal with any qualitative or mixed methods data, so, for the purposes of this study, the quantitative methodology provided the best approach. A quantitative methodology allowed the identification of differences between two variable groups as in the implementation of a one-to-one computer laptop program, and student achievement scores.

Remaining Chapter 3 sections include a detailing of study participants including defining the target population. The population from which the sample was drawn is specified, and procedures for selecting the sample are outlined. The study instrument is examined next, and then procedures are provided. Examination of study procedures include detailed information on the study design, as well as data collection procedures, and conclude with a section on data analysis procedures.

Participants

The population of interest for this study involved all eighth-grade students of low SES in the state of Washington. The target population for this study involved all 2016 and 2018 eighth-grade students of low SES in one Washington school district. The sample for this study involved all 2016 and 2018 eighth-grade students of low SES in one Washington school district for whom SBAC summative ELA and/or mathematics scores exist. The unit of analysis involved eighth-grade students. The target population for this study involved all eighth-grade students of low SES who participated in the one-to-one laptop program in the participating school district in Washington from 2015 to 2018. The population from which the sample was actually be drawn involved all 2016 and 2018 eighth-grade students of low SES, with a valid SBAC summative assessment ELA and/or mathematics score in the target Washington school district, who also participated in the one-to-one laptop program during the designated years. Low SES was defined by Tan et al. (2020) as an individual's location in the societal hierarchy with the least amount of money, lowest education, and no respectable form of employment which is based on factual reporting as it relates to a shared public benchmark of SES. For purposes of this study's sample, low SES is defined as students with documentation in the school district's student data system of meeting the requirements for free or reduced lunch status.

This study utilized available archival secondary data and, therefore, did not require any recruitment of participants. Sampling procedures for this study involved first identifying and then selecting the sample. This included the identification of students of low SES by the participating district using district determined free and reduced lunch status. All eighth-grade students of low SES were included with no exclusion based on age, gender, ethnicity, or other demographic marker. A purposive sampling strategy was selected and utilized for this study. Purposive sampling occurs when selection of the units is based on the judgement of the researcher according to unit characteristics (Laerd Statistics, 2023g, 2023h, 2023i). Purposive sampling allowed for the selection of specific achievement scores of only eighth-grade students of low SES for specific years based on participation for a specific length of time in the one-to-one laptop program. One purposive sampling screening criterion was free or reduced lunch status. This criterion was established because evidence exists in the literature supporting the idea that individuals of low SES are more vulnerable to barriers caused by the problem of the digital divide (Bach et al., 2018; Shami-Iyabo, 2020; van Dijk, 2006).

The purposive sampling strategy for the study involved utilization of two criteria applied to the target population, which involved 2016 and 2018 eighth-grade test scores in the target district. These criteria were free and reduced lunch status based on district records and SBAC summative test scores for ELA and/or mathematics utilizing district records. The procedure that was used to identify students in the sample as students of low SES involved filtering summative SBAC test score data in the Washington State Assessment Portal by the free and reduced lunch status of each student as determined by the participating school district.

The primary plan to obtain the sample was confirmed by the school district's Director of Curriculum and Assessment. To obtain site authorization, the researcher completed the participating school district's Request for Research Proposal form. Information describing the nature of this research as well as how this research may benefit the school district was provided in the Request for Research Proposal form. Site authorization was obtained from the participating school district. The participating school district owns district SBAC summative archival student achievement scores and provided approval for use of these data for this research.

The specific data for the sample that were requested involved all ELA and mathematics SBAC summative scores for 2015-2016 eighth-grade students of low SES who participated in the target school district's one-to-one laptop program for 1 year from 2015-2016 and all ELA and mathematics SBAC summative scores for 2017-2018 eighth-grade students of low SES who participated in the one-to-one laptop program for 3 years from 2015-2018. Four Excel spreadsheets were requested from the participating school district and provided to the researcher by the Director of Curriculum and Assessment. These included two Excel spreadsheets that provided eighth-grade SBAC summative ELA scale scores for 2016 and 2018 and two Excel spreadsheets for eighth-grade SBAC summative mathematics scale scores for 2016 and 2018.

Instruments

This quantitative nonexperimental causal-comparative study included two instruments. These two instruments were the SBAC summative ELA and the SBAC summative mathematics eighth-grade tests, measuring student academic achievement using scale scores. SBAC summative assessments in ELA and mathematics are administered by the state of Washington, as an accountability measure (SBAC, 2020). The SBAC summative assessments are given to students in Grades 3 to 11 at the end of the year to measure students' progress toward college and career readiness in ELA and mathematics (SBAC, 2020).

Instrument Development and Construction

The two instruments, ELA and mathematics eighth-grade tests, were developed with input from partner states and territories (SBAC, 2018). The assessments were constructed as a way to assess the CCSS, which were not designed or intended specifically for online assessment (SBAC, 2018). Therefore, SBAC content experts developed Content Specifications for ELA/Literacy and mathematics (SBAC, 2018). The process yielded a distillation of elements from the CCSS that resulted in items that could be assessed (SBAC, 2018). Each assessment item was carefully aligned to a claim, target, and a CCSS (SBAC, 2018). The summative assessment for each content area was then developed into an online platform (SBAC, 2018).

Preview of Instrument Validity and Reliability

SBAC testing instruments were developed in partnership with school districts from across the United States over the course of 4 years from 2010 to 2014 (SBAC, 2015). The SBAC tests have been utilized by school districts across the United States since 2015 when the online tests launched. The purposes of the SBAC summative assessment development are to provide valid, reliable, and fair information about the following:

1. Students' ELA/literacy and mathematics achievement with respect to the CCSS measured by the ELA/literacy and mathematics summative assessments in grades 3 to 8 and high school;
2. Whether students prior to grade 11 have demonstrated sufficient academic proficiency in ELA/literacy and mathematics to be on track for achieving college-readiness;
3. Whether grade 11 students have sufficient academic proficiency in ELA/literacy and mathematics to be ready to take credit-bearing, transferable college courses after completing their high school coursework;
4. Students' annual progress toward college- and career-readiness in ELA/literacy

and mathematics;

5. How instruction can be improved at the classroom, school, district, and state levels;

6. Students' ELA/literacy and mathematics proficiencies for federal accountability purposes and potentially for state and local accountability systems;

7. Student achievement in ELA/literacy and mathematics that is equitable for all students and targeted student groups. (SBAC, 2015, p. 4)

The SBAC conducts annual reviews of testing instruments to ensure validity and reliability (SBAC, 2016). SBAC has a validity framework for SBAC summative assessments that are cross referenced with validity evidence from the CCSS, including test content, internal structure, the response process, and relation to other variables (SBAC, 2019). In addition, the SBAC summative assessment's reliability and precision is validated through the analysis of measurement error both in simulated and operational testing conditions (SBAC, 2019).

The SBAC (2015) noted that reliability for a testing instrument is called marginal reliability: "Marginal reliability is calculated and estimated as one minus the ratio of mean error variance to observed score variance" (p. 4). Specific reliability statistics for SBAC measurement instruments are shared in the SBAC (2015) as follows:

Statistics for simulations computed include the following:

- Bias: the statistical bias of the estimated theta parameter. This is a test of the assumption that error is randomly distributed around true ability. It is a measure of whether scores systematically underestimate or overestimate ability. (pp. 2-4)

$$bias = N^{-1}\sum_{i=1}^{N}(\theta_i - \hat{\theta}_i) \quad \textbf{(1)}$$

where θ_i is the true score and $\hat{\theta}_i$ is the estimated (observed) score.

- Mean squared error (MSE): This is a measure of the magnitude of difference between true and estimated theta. (pp. 2-4)

$$MSE = N^{-1}\sum_{i=1}^{N}(\theta_i - \hat{\theta}_i)^2 \quad \textbf{(2)}$$

where θ_i is the true score and $\hat{\theta}_i$ is the estimated (observed) score.

- Significance of the bias: Indicator of the statistical significance of bias. (pp. 2-4)

$$\text{var}(bias) = \frac{1}{N(N-1)}\sum_{i=1}^{N}(\theta_i - \bar{\hat{\theta}}_i)^2 \quad \textbf{(3)}$$

where, $\bar{\hat{\theta}}_i$ is an average of the estimated theta.

- Average standard error of the estimated theta: This is the average of the simulated standard error of measurement. It is the marginal reliability for the simulated population. (pp. 2-4)

Significance of the bias is then tested as:

$$z = bias / \sqrt{\text{var}(bias)} \quad \textbf{(4)}$$

- A p-value for the significance of the bias is reported from this z test.

- Standard error of theta at the 5th, 25th, 75th, and 95th percentiles. (pp. 2-4)

The average standard error is computed as:

$$mean(se) = \sqrt{N^{-1}\sum_{i=1}^{N} se_i^2} \quad \textbf{(5)}$$

where $se(\hat{\theta}_i)^2$ is the standard error of the estimated θ for individual i.

- Percentage of students' estimated theta falling outside the 95% and 99% confidence intervals. To determine the number of students falling outside the 95%

and 99% confidence interval coverage, a t-test is performed. The *t* test is performed as follows. (pp. 2-5):

$$t = \frac{\theta_i - \hat{\theta}_i}{se(\hat{\theta}_i)} \quad \textbf{(6)}$$

where $\hat{\theta}$ is the ability estimate for individual *i*, and θ is the true score for individual *i*. The percentage of students' estimated theta falling outside the coverage is determined by comparing the absolute value of the *t*-statistic to a critical value of 1.96 for the 95% coverage and to 2.58 for the 99% coverage.

The ELA testing instrument was presented in research by Smith and Wheeler (2019) and included the use of ELA test results to place students in a college student population in Washington State. ELA 11th-grade assessment results were used to determine student placement in college-level English courses. In addition, ELA and mathematics testing was used by Meyer (2017) in a Colorado student population, which further supported the reliability of the ELA and mathematics testing instrument for use in the Washington student population. In 2020, Singh et al. conducted a study to investigate the achievement patterns of the Asian Pacific Islander subgroup of Hawaiian elementary students. Research by Singh et al. provided further evidence of reliability of the SBAC summative assessment tool.

Validity

The SBAC summative ELA and mathematics eighth-grade test instruments were used to measure the dependent variables for the study. According to Frey (2018), "Validity is the extent to which a test measures what it claims to measure, and the extent to which a claim, result, inference, or argument is well founded" (p. 1772). The SBAC summative ELA and mathematics eighth-grade test instruments were developed based on research, and have gone through rigorous testing for validity (SBAC, 2015). Both the summative ELA and mathematics eighth-grade test instruments were specifically designed to measure student achievement and were applied as designed based on the use of archival data in this research.

As shared by the SBAC (2015), validation for the SBAC summative test included an indepth process of accumulating evidence in support of proposed score interpretations and usages. The validation process was not based on a single study. Validation of the SBAC summative ELA and mathematics eighth-grade test instruments has included multiple investigations and various types of evidence over time (SBAC, 2015). According to the SBAC, the process of developing the testing instruments began with test design, including item development, field-testing and item analysis, test scaling and linking, test scoring, and reporting.

Evidence supporting the validity of the SBAC summative ELA and mathematics eighth-grade test instruments is based in the research and principles documented in the Standards for Educational and Psychological Testing (SBAC, 2015). According to the SBAC (2015), the Standards for Educational and Psychological Testing are considered the gold standard for professional consensus on development and evaluation educational and psychological testing. Elements essential to validity, as noted by the Standards for Educational and Psychological Testing, were included in the development of the SBAC summative ELA and mathematics eighth-grade test instruments (SBAC, 2015). The essential elements include the following: accurate test construction, score reliability, test scoring and administration, accuracy of score scaling, equating, and standard setting, assurance of equity and fairness in testing without barriers to access or participation (SBAC, 2015). The SBAC summative test is administered to students in Grades 3 to 11 annually in the spring by all public school districts across Washington State. The SBAC summative test is used to determine the extent to which ELA and mathematics skills and concepts have been mastered over the course of a school year. SBAC summative scores are utilized by teachers to identify academic areas in need of additional support as well as areas in which students may benefit from extended learning beyond grade-level standards.

This study used a causal-comparative design and sought to determine to what extent differences existed in low-SES eighth-grade students' ELA and mathematics summative assessment achievement outcomes based on years of participation in a Washington school district's one-to-one laptop program. According to the SBAC (2016), the data showed a marginal validity of .922 in ELA from a sample of 699,578 eighth-grade students, and a marginal validity of .922 in mathematics from a sample of 693,846 eighth-grade students. According to the SBAC (2018), the data showed a marginal validity of .926 in ELA from a sample of 682,763 eighth-grade students and a marginal validity of .931 in mathematics from a sample of 680,858 eighth-grade students (see Table 1). Data for this study were collected from the Washington Comprehensive Assessment Portal. ELA and mathematics 2016 and 2018 SBAC summative archival data were used to measure achievement of eighth-grade students of low SES who participated in 1 year compared to 3 years of a one-to-one laptop program.

Considering the SBAC development procedures, its current use in the state of Washington, and validity statistical data of the SBAC summative ELA and mathematics eighth-grade test instruments, and given the measurement invariance has been addressed, the SBAC was appropriate for use in this study. Frey (2018) shared that measurement invariance pertains to the question regarding if the specific instruments are measuring the same phenomenon consistently over time and location. The author noted that instruments with variable measurement properties applied over time and location pose a distinct threat to the validity of measurement (Frey, 2018). This results in a threat to the validity of the overall assessment. Development of the SBAC summative ELA and mathematics eighth-grade test instruments based on the Standards for Educational and Psychological Testing, and the fact that the data collected for this study were archival, resulted in no cause for concern with validity in this research. The SBAC (2015) noted that SBAC summative assessment is specially designed to provide accurate measures of student achievement based on the CCSS that are valid, reliable, and fair.

Table 1

Summative Scale Marginal Reliability Estimates

Item	No.	Total score	Claim 1	Claim 2	Claim 3	Claim 4
English language arts						
Grade 3	667,449	0.928	0.752	0.787	0.552	0.669
Grade 4	695,714	0.925	0.738	0.782	0.539	0.681
Grade 5	701,022	0.930	0.748	0.798	0.576	0.707
Grade 6	706,541	0.922	0.750	0.805	0.552	0.684
Grade 7	688,809	0.924	0.771	0.786	0.534	0.665
Grade 8	682,763	0.926	0.753	0.785	0.549	0.684
High school	613,163	0.926	0.727	0.786	0.532	0.674
Mathematics						
Grade 3	668.250	0.948	0.903	0.677	0.733	0.677
Grade 4	697,406	0.948	0.897	0.670	0.700	0.670
Grade 5	702,951	0.938	0.894	0.573	0.666	0.573
Grade 6	706,567	0.938	0.880	0.648	0.718	0.648
Grade 7	690,306	0.927	0.888	0.600	0.621	0.600
Grade 8	680,858	0.931	0.885	0.598	0.682	0.598
High school	643,958	0.906	0.881	0.570	0.572	0.570

Allen (2017) opined that extrinsic validity pertains to the ability to apply the instrument in other studies with fidelity. The SBAC summative ELA and mathematics testing instruments have been used in research by Smith and Wheeler (2019) and Meyer (2017), which further supported the extrinsic validity of the SBAC summative ELA and mathematics testing instrument. In 2020, Singh et al. conducted a study to investigate the achievement patterns of the Asian Pacific Islander subgroup of Hawaiian elementary students. The sample included archival data from 4,625 third-grade students, 14,154 fourth-grade students, and 14,146 fifth-grade students from 196 public elementary schools across Hawai'i (Singh et al., 2020). Study findings highlighted the need for early reading difficulty identification to be paired with evidence-based reading interventions focused on prerequisite reading skills. Research by Singh et al. provided further evidence of construct validity and extrinsic validity of the SBAC summative assessment tool.

Reliability

SBAC test reliability is estimated through simulations using the SBAC operational summative item pool. The SBAC (2018) reported the following: "Reliability estimates reported in this section are derived from internal, IRT-based estimates of the measurement error in the test scores of examinees (MSE) and the observed variance of examinees test scores on the θ-scale ($v$ar(θ))" (p. 32). The formula for the reliability estimate is as follows:

$$\hat{\rho} = 1 - \frac{MSE}{var(\hat{\theta})}.$$

Steps to be taken to ensure the reliability of the results of the study included utilizing only SBAC summative student achievement scores as provided by the participating school district. Allen (2017) noted that steps to increase reliability include standardization of the test administration process and testing procedures, careful calibration of measurement devices, eliminating weak scale items, adding scale items that are of equal strength to the original measures, implementing standardized procedures for coding, and making sure that coders are well trained (Allen, 2017). Since the SBAC summative student achievement data used in this study were archival, there was no potential for reliability issues pertaining to test administration, calibration of measurement devices, or changes to scale items. All measurements were assumed to be reliable since the test scores were archival and the researcher had no contact with the testing instrument or process.

Structure of the Instrument

The structure of the SBAC summative ELA and mathematics eighth-grade test instruments include scale scores and achievement levels. According to the SBAC (2020) reported the following:

> After students take the Smarter Balanced assessments, their results are reported in scale scores. A scale score is the student's overall numerical score. These scores fall on a continuous scale (from approximately 2000 to 3000) that increases across grade levels. Scale scores can be used to illustrate students' current level of achievement and their growth over time. (p. 24)

The type of data collected were archival numerical summative scale scores from 2016 and 2018 for eighth-grade SBAC ELA and mathematics achievement for students of low socioeconomic status who participated in 1 or 3 years of a one-to-one laptop program's implementation in a Washington school district. The overall SBAC summative assessment marginal reliability for eighth-grade ELA was 0.924 and 0.928 for eighth-grade mathematics (SBAC, 2017). For purposes of this study, the overall ELA score (a composite score across all four claims) and the overall mathematics score (a composite score across all four claims) were used (SBAC, 2018).

SBAC summative ELA and mathematics eighth-grade test instrument structure presents scaled scores achieved at one of four achievement levels (SBAC, 2018). Achievement levels are arranged based on scaled scores that correlate to each achievement level for ELA and mathematics (SBAC, 2018). Achievement levels reflect the knowledge and skills students display at each grade and Achievement Levels 1 to 4 (SBAC, 2018). Specifically, students performing at Levels 3 and 4 on summative SBAC assessments are considered demonstrating the knowledge and skills necessary for their grade level to be college and career ready by graduation (SBAC, 2018).

Item Types and Questions

The type and number of questions a student receives varies by the number of correct responses each student provides and the level of difficulty they achieve as they progress through the assessment (SBAC, 2015). A combination of question types collectively makes up the computer adaptive test and a performance task assessment for each ELA and mathematics assessment. The summative assessment for each content area consists of two parts: a computer adaptive test and a performance task. The performance task is administered on a computer but is not computer adaptive (SBAC, 2018).

Question types for both ELA and mathematics included in the computer adaptive portion of the assessment are drag-and-drop, drawing an object, or editing text (SBAC, 2015). Selected-response questions prompt students to select one or more options from a group (SBAC, 2015). Constructed-response items require that students collect evidence based on their understanding of an assessment question and demonstrate their knowledge by producing text or a numerical response (SBAC, 2015). Performance tasks include the application of knowledge and skills in response to questions addressing complex real-world problems requiring demonstration of critical-thinking and problem-solving skills (SBAC, 2015).

Item types and questions included on the SBAC summative assessments are arranged by claim. The SBAC summative ELA assessment measures students’ progress toward college and career readiness in ELA in four components: Claim 1: reading, Claim 2: writing, Claim 3: speaking and listening, Claim 4: research/inquiry, and language, which is embedded in both Claims 1 and 2 (SBAC, 2018). The SBAC summative mathematics assessment measures students' progress toward college and career readiness in mathematics in four components: Claim 1: concepts and procedures, Claim 2: problem solving, Claim 3: communicating reasoning, Claim 4: modeling and data analysis, with Claims 2 and 4 in mathematics reported jointly (SBAC, 2018).

Scoring and Statistical Scale of Measurement

The SBAC summative ELA and mathematics eighth-grade test instruments are scored using the mean of the scored items (SBAC, 2019). The statistical scale of measurement is interval of the data obtained from the instrument. The estimates of student proficiency and item difficulty from the calibration program PARSCALE are on a scale where student ability has a mean of 0 and a standard deviation of approximately 1. This scale is called the theta scale, and a student's proficiency on this scale is referred to as the student's theta. Estimates of student proficiency are transformed onto a four-digit scale that is more meaningful to stakeholders. The equation for this transformation is Scale Score = $(\theta * \text{slope}) + \text{intercept}$. Table 2 presents the slope and intercept for English language arts and mathematics.

Table 2

Slope and Intercept for English and Math

Subject	Grade	Slope	Intercept
English	3 to 8	85.8	2508.2
Math	3 to 8	79.3	2514.9

Procedures

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Archival data from the SBAC's ELA and mathematics were used to measure the eighth-grade student achievement scores of students of low SES who participated in 2016 as Year 1 compared to 2018 as Year 3 of a one-to-one laptop program. Data were provided to the researcher by the Director of Curriculum and Assessment at the participating school district.

Archival data also included demographic data. The data requested from the participating school district involved ELA and mathematics summative SBAC achievement scores from eighth-grade students of low SES for group classification related to the dependent variables. The use of demographic data was to provide a profile of the sample, and the specific demographic data collected were relevant to the topic. The specific demographic data collected included gender, free or reduced lunch status, and grade level.

Design

The research design for this study was causal-comparative. According to Brewer and Kubn (2010), the causal-comparative study design seeks to determine relationships between independent and dependent variables after the occurrence of an action or event. Schenker and Rumrill (2004) pointed out that causal-comparative research is nonexperimental, and uses preexisting groups to explore differences between or among those groups on dependent variables. This research utilized archival student test score data to examine the extent to which a statistical difference existed in eighth-grade students' ELA and mathematics summative assessment achievement outcomes for groups established based on years of participation in a Washington school district's one-to-one laptop program. Brewer and Kubn noted the causal-comparative study design, also known as ex post facto research, seeks to determine relationships between independent and dependent variables after the occurrence of an action or event.

Empirical references from current studies support the use of a causal-comparative design for this research. Meyer (2017) conducted a quantitative causal-comparative study to determine if any differences existed between two groups of students over time, to determine whether a one-to-one laptop program had any influence over student achievement. Meyer's study results determined that student achievement on reading, writing, and mathematics standardized tests was higher for students participating in a one-to-one technology program. However, increases in student achievement were small and did not yield statistically significant composite scores through time (Meyer, 2017).

Zia et al. (2017) opined that a causal-comparative study employs statistical testing to determine differences between dependent and independent variables. Research by Zia et al. implemented a causal-comparative design to compare two groups as public and private schools in Lahore, Pakistan. The study focused on the usage of ICTs in schools to determine improvement of communication skills and level of knowledge (Zia et al., 2017). Zia et al. noted that all hypotheses were accepted, and results were statistically significant in supporting the importance of ICTs for the improvement of communication skills and level of knowledge. Private school students had greater access to and use of ICTs for learning over public school students, resulting in improvement of communication skills and level of knowledge for private school students (Zia et al., 2017).

Frey (2018) shared a detailed description of causal-comparative research in that it begins with what is known about, or an expected outcome. A group distinction is then compared as the potential cause for the resulting effect (Frey, 2018). Frey also noted that the independent variable is categorical, and two or more groups are compared to test for causality. The rationale behind the decision to select a causal-comparative design is that this study has two groups of students for each research question for which the potential effect of an increase or decrease in student achievement on the SBAC summative ELA and mathematics assessments will determine causality for the implementation of a one-to-one laptop program. Only a quantitative methodology can support this causal-comparative study design for the comparison of two groups after the occurrence of an event (Salkind, 2010a, 2010b), such as the implementation of the one-to-one laptop program. Therefore, the causal-comparative design was the best design to collect data, answer the research questions, and test the hypotheses.

The research questions for the study sought to determine the extent to which there was a statistically significant difference, if any, between 2016 eighth-grade ELA and mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district. The resulting information will help to address the research problem of the digital divide. Selecting a causal-comparative design is based on the appropriateness of the design to address the research questions and data for each variable. Given the reasons for using causal-comparative design and the nature of this study's research questions and research problem, causal-comparative was the appropriate design for the study.

Other research designs considered for this study included descriptive research, correlational research, and experimental research designs. A descriptive design seeks to describe phenomena as they currently exist (Salkind, 2010a). Thus, a quantitative descriptive design did not apply to this study. Descriptive research provides a detailed account of a social setting, a group of people, a community, a situation, or some other phenomenon (Thomlinson, 2001). This research does not describe situations or events, making descriptive methodology an inappropriate choice. Correlational research attempts to determine the extent of a relationship between two or more variables using statistical data (Gavin, 2008). This research did not investigate relationships between variables, but rather differences between groups, and, therefore, the correlational design was not appropriate for this study. An independent variable is manipulated in experimental research to determine the effects on the dependent variables (Allen, 2017). This research did not experiment on groups, and the independent variables were not manipulated.

Data Collection

The nature of all data collected was secondary. Data were collected from the Washington Comprehensive Assessment Portal. Data were collected for each variable from the participating school district's Washington Comprehensive Assessment Portal by the participating school district. The participating school district cleared the data of all student identifiers before providing the information to the researcher. Data required for the study were provided to the researcher by the Director of Curriculum and Assessment. The data were archival student test score data from the district's Washington Comprehensive Assessment Portal account provided to the researcher in a spreadsheet format after the necessary permissions were obtained, including university approval. No live participants were part of the study. Only archived data were utilized. The following steps were used for data collection:

1. Prior to data collection, approval was obtained from the participating school district and NSU's Institutional Review Board.

2. Site authorization was requested for permission to conduct research in the district by contacting the district's Director of Curriculum and Assessment. Final approval required the submission and approval of the school district's application to conduct research. The document required disclosure of the specifics of how data would be used, potential benefits to the district, and the premise of the research study.

3. A request for data was provided to the district's Director of Curriculum and Assessment. An Excel Spreadsheet was designed and provided to the district's Director of Curriculum and Assessment detailing the required data including eighth-grade free and reduced lunch status 2016 SBAC summative ELA scale scores, free and reduced lunch status 2016 SBAC summative mathematics scale scores, free and reduced lunch status 2018 SBAC summative ELA Scale scores, and free and reduced lunch status 2018 SBAC summative mathematics scale scores.

4. To ensure confidentiality, no personally identifying information was requested, and the data received by the researcher did not include any individual student identifiers.

5. The data were organized into four groups for analysis purposes, two groups for each of two research questions. Group 1 consisted of free and reduced lunch status 2016 ELA scale scores for eighth-grade students in a Washington school district. Group 2 consisted of free and reduced lunch status 2018 ELA scale scores for eighth-grade students in a Washington school district. Group 3 consisted of free and reduced lunch status 2016 mathematics scale scores for eighth-grade students in a Washington school district. Group 4 consisted of free and reduced lunch status 2018 mathematics scale

scores for eighth-grade students in a Washington school district.

5. Data management procedures included that, to protect the identity of students, teachers, the school district, and confidentiality of all school records, data for this study did not include names or student identification numbers and were used by the researcher for the purpose identified by this study. Data were kept in a secured safe in the researcher's home and were managed using two electronic sources including a flash drive and backup external hard drive, and all hard copy documents were kept in an unlabeled folder. All digital data were stored in the researcher's password-protected computer with only the researcher knowing the password. All hard copy data were locked in a safe with only the researcher having the combination for the safe.

Data Analysis

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Data analysis included a descriptive and inferential statistical analysis using an independent-samples *t* test to test the research hypothesis for each research question by determining the statistical difference between groups at the .05 level of significance. Descriptive statistics were appropriate for describing data (Ritter et al., 2013). Descriptive statistics included the number of scores for each of the ELA and mathematics groups, the range, and mean scores for each of the groups. The inferential statistical analysis utilized the independent-samples *t* test. Inferential statistics are not used to draw conclusions, but rather to convey if conclusions drawn are supported by the data (Ritter et al., 2013).

When data are analyzed to determine if a significant difference exists between groups, the independent-samples *t* test is relied on most frequently in inferential statistics (Mills & Gay, 2019). Assumptions associated with an independent-samples *t* test are examined in the data analysis phase of the study. Independent-samples *t*-test assumptions include homogeneity of variances and that the dependent variable is normally distributed for each independent variable group. The data are examined to identify potential violations in the statistical assumptions of an independent-samples *t* test. The Levene's test is used to test the null hypothesis to determine if the variance is equal across all groups. A Levene's test for homogeneity of variance provides both an *F* statistic and a *p* value (Laerd Statistics, 2023d, 2023f). A violation of the assumption will yield a *p* value less than .05 (Laerd Statistics, 2023d). The Statistical Product and Service Solutions (SPSS) nonparametric tests are used in the event assumptions are not met using either the independent-samples *t* tests or the Levene's test (Kim, 2015).

Research Question 1 Analysis. What is the statistical difference, if any, between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district? The variables were years of participation in a Washington school district's one-to-one laptop program and eighth-grade ELA achievement scale scores based on archival SBAC summative data from the Washington Comprehensive Assessment Portal. The data required for the corresponding hypotheses included 2016 and 2018 eighth-grade SBAC summative ELA achievement scale scores for students of low SES. The null hypothesis stated there is no statistically significant difference in 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district. The alternate hypothesis stated there is a statistically significant difference in 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district.

Data were entered into SPSS to conduct both the descriptive and inferential analyses. The descriptive data, including frequency, range, mean, and standard deviation, were calculated for each of the two Research Question 1 groups. These groups included eighth-grade ELA 2016 scale scores for students of low SES who participated for 1 year and eighth-grade ELA 2018 scale scores for students of low SES who participated for 3 years in a one-to-one laptop program. The descriptive data analysis results were presented in both a narrative and in a table. Next, an independent-samples *t* test with an appropriate confidence level of 95% was executed. This procedure was used to determine the extent to which a statistical difference existed between groups (Laerd Statistics, 2023d). The inferential data analysis results were presented in both a narrative and in a table.

Research Question 2 Analysis. What is the statistical difference, if any, between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district? The variables were years of participation in a Washington school district’s one-to-one laptop program and eighth-grade mathematics achievement scale scores based on archival SBAC summative data from the Washington Comprehensive Assessment Portal. The data required for the corresponding hypotheses included 2016 and 2018 eighth-grade SBAC summative mathematics achievement scale scores for students of low SES. The null hypothesis stated there is no statistically significant difference in 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district. The data required for analysis included 2016 and 2018 eighth-grade SBAC summative mathematics achievement scale scores from students of low SES. The alternate hypothesis stated there is a statistically significant difference in 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district. The data required for analysis included 2016 and 2018 eighth-grade SBAC summative mathematics achievement scale scores from students of low SES. To examine students' mathematics achievement, data from an Excel spreadsheet were entered into SPSS. SPSS software was used to conduct an independent-samples *t*-test statistical analysis of the data.

Data were entered into SPSS to conduct both the descriptive and inferential analyses. The descriptive data, including frequency, range, mean, and standard deviation, were calculated for each of the two Research Question 2 groups. These groups included eighth-grade mathematics 2016 summative scale scores for students of low SES who participated for 1 year and eighth-grade mathematics 2018 summative scale scores for students of low SES who participated for 3 years in a one-to-one laptop program. The descriptive data analysis results were presented in both a narrative and in a table. Next, an independent-samples *t* test with an appropriate confidence level of 95% was executed. This procedure was used to determine the extent to which a statistical difference exists between groups (Laerd Statistics, 2023d). The inferential data analysis results were presented in both a narrative and in a table.

Data Analysis Steps for Each Research Question. The data analysis steps for each research question were as follows:

1. Data file preparation: Cleaning and compiling the data, including removing outliers, removing any duplications, addressing missing data, and downloading to SPSS (Allen, 2017).

2. Import data into SPSS statistical software program.

3. Examine data after transferring from the Excel spreadsheet provided by the participating district to SPSS to ensure the researcher accurately transferred all data correctly.

4. Summative scale scores will undergo descriptive analysis to determine measures of central tendency including the mean scale score for each group. Measures of central tendency include mean, median, and mode, and allow for the calculation of a single score to reflect performance of the sample population (Allen, 2017).

5. The mean scale scores for each of the two groups for each of the two research questions were utilized to conduct an independent-samples *t* test, which is an inferential statistic used when determining if a statistically significant difference exists between the means of two independent groups (Laerd Statistics, 2023d). To detect a medium effect size, the statistical significance level must be 0.05 for a 95% confidence level (Allen, 2017).

6. Data were examined to identify potential independent-samples *t*-test violations of assumptions. There are six independent-samples *t*-test assumptions that must be passed. Violations of data assumptions will be resolved using a non-parametric test. Non-parametric tests are utilized in the event the assumptions of a parametric test are violated

(Salkind, 2010a). Levines' test is the appropriate non-parametric test to determine the extent of difference between the mean scale scores of groups (Frey, 2018). All assumptions for each research question will be examined. The assumptions that will be considered and satisfactorily resolved were as follows.

Assumption 1. The dependent variable should be measured on a continuous scale, whether at the interval or ratio level (Laerd Statistics, 2020). Dependent variables for this study were ELA achievement and mathematics achievement based on 2016 and 2018 ELA and mathematics SBAC summative assessments for students of low SES. The dependent variables were measured on a continuous scale at the interval level as Variable 1: ELA achievement for the scaled score range of 2288 to 2769 and Variable 2: mathematics achievement for the scaled score range of less than 2265 to greater than 2802. Variables were measured at the ratio level as the eighth-grade highest obtainable scale score of 2769 for ELA and 2802 for mathematics and lowest obtainable scale score of 2288 for ELA and 2265 for mathematics. According to the SBAC (2019), scores do not fall below zero. The SBAC (2015) reported, “Scores above HOSS or below LOSS are assigned HOSS and LOSS values. This provides a limit to the score range, which is desired in public reporting” (pp. 2-3).

Assumption 2. The independent variable should include two categorical, independent groups (Laerd Statistics, 2020). The independent variable for this study was years of participation in a Washington school district’s one-to-one laptop program. The two categorically independent groups were 1 year of participation as 2016 and 3 years of participation as 2018. Measurement was dichotomous, as only two values were possible: 1 year of participation and 3 years of participation.

Assumption 3. There should be independence of observations with no relationship between groups (Laerd Statistics, 2020). There was independence of observations as there was no relationship between 2016 eighth-grade students and 2018 eighth-grade students. Independence of observations includes that there are different participants in each group with no participant being in more than one group (Laerd Statistics, 2020).

Assumption 4. No significant outliers should exist (Laerd Statistics, 2023c). If single data points within this study data are found to not follow the usual data pattern, SPSS statistics will be utilized to run an Explore… procedure on the data to detect possible outliers (Laerd Statistics, 2023c). The SPSS Statistics Explore… procedure generates a boxplot that will be used to determine if outliers exist. Outliers may have a negative effect on the independent *t* test, resulting in reduced validity of results (Laerd Statistics, 2023b, 2023c). When outliers are present, the data should be checked for data entry errors, measurement errors such as equipment malfunction or out of range values should be assessed, and, if an outlier is neither data entry nor measurement error related, a genuinely unusual value is most likely (Laerd Statistics, 2023c). If outliers exist, independent-samples *t* tests should be run in SPSS statistics, with and without the outliers included (Laerd Statistics, 2023c). Next, the results are compared to determine whether the two sets of results differ sufficiently resulting in different conclusions being drawn from the data. If both result in a statistically significant result, the outlier may be kept in the data (Laerd Statistics, 2023c). In the event both results are not statistically significant, the decision to remove the outlier may be considered (Laerd Statistics, 2023c). All removed data point values should be presented along with any potential impacts that may result from removal (Laerd Statistics, 2023c).

Assumption 5. For each independent variable group, the dependent variable should be approximately normally distributed (Laerd Statistics, 2020). For this study, the data near the mean should be more frequent in occurrence than data far from the mean. To be considered a normal distribution, the bell curve must be entirely symmetrical around the mean (Allen, 2017). According to Allen (2017), a standard normal distribution includes that approximately 68.3% of all data points should fall within one standard deviation of the mean, 95.4% of all data points should fall within two standard deviations of the mean, and 99.7% of all data points should fall within three standard deviations of the mean. Testing for normality will be done using the Shapiro-Wilk test of normality, using SPSS statistics.

Assumption 6. There should be homogeneity of variances (Laerd Statistics, 2020). To achieve homogeneity of variances, the variances between the two groups as 1-year participation and 3 years of participation should be equal. This quality is known as the assumption of homogeneity of variance (Nishishiba et al., 2014). This assumption was tested in SPSS statistics using Levene's test for homogeneity of variances. The *t*-test calculation was used to determine if a statistically significant difference existed between the SBAC summative achievement scale score means of the two groups established for each research question. The test of and decisions for the hypotheses was based on an inferential statistical (i.e., *t* test) analysis. A *p* value less than .05 would be considered statistically significant and would result in the rejection of the null hypothesis and failure to reject the alternate hypothesis. A *p* value greater than .05 would be considered not statistically significant and would result in a decision to fail to reject the null hypothesis.

Final results are reported in Chapter 4, including explanation of findings based on the data analysis. Results are presented in table format when necessary and discussed in response to the research questions. The results of this study are expected to contribute to the literature by increasing the understanding of differences in student achievement for groups established based on years of participation in a one-to-one laptop program.

Assumptions and Delimitations

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. To achieve this purpose, assumptions and delimitations must be addressed. Assumptions are ideas that the researcher may have taken for granted (Ellis & Levy, 2009). Delimitations are those limitations intentionally set by the research authors. The researcher should present alternatives and reasons for rejecting the delimitations so that the readers are fully informed. Known assumptions and delimitations were addressed in this study, beginning with assumptions.

Assumptions

Assumptions were made for this study. The statistical procedure of the independent-samples *t* test includes specific assumptions: independent observations, equal variances in groups, and normality. Salkind (2010a) noted specifically that observations in this study are independent and not predictive of other observations within the study, homogeneity of variance must occur in each of the populations, with samples drawn from a population following a normal distribution, and finally, unbiased sampling should occur from the target population. The assumption of homogeneity of variance was included as the groups of low SES eighth-grade student SBAC summative scores and years of participation in a one-to-one laptop program are varied. Researchers should be forthcoming about assumptions in order to demonstrate that all aspects of the study have been evaluated (Ellis & Levy, 2009). An additional assumption pertaining to this study is that archival student achievement data provided by the participating school district to the researcher will be accurate. The assumption is justified as all SBAC summative data is housed in a secure website hosted by the Office of the Superintendent of Public Instruction for the state of Washington and made available to the school district for access by the Director of Curriculum and Assessment to maintain confidentiality of student data.

Delimitations

Delimitations are within the researcher's control. McGregor (2018) defined delimitations as a boundary intentionally created by the researcher, allowing certain things in or out. This defines the project scope before research begins (McGregor, 2018). Delimitations are not positive or negative, but instead a detailed account of the researcher's reasoning which promotes the purpose of the study, the research design, and the foundational framework. A delimitation for the study is that only eighth-grade SBAC summative scaled ELA and mathematics scores from students of low SES were analyzed. A second delimitation is that the study was limited to eighth-grade students of low SES. A third delimitation is that only one school district was included based on access to archival data. The fourth delimitation addresses the timeline of only including years 2016 through 2018, which aligns with the participating school district's one-to-one laptop computer implementation in Grade 8. Justification for these delimitations is that they narrow the focus, making the study possible to achieve.

Validity was addressed for the study as a whole. According to Salkind (2010a), threats to validity include the potential for a hypothesis to be tested in a way not originally intended by the researcher. Salkind noted two matters of validity that may arise during research: reliability of outcomes and generalizability. Specifically, Salkind shared that reliability of the research outcomes must be able to be applied to research of similar design, and that outcomes to the study population must be generalizable.

Frey (2018) opined that external and internal validity must be addressed by the researcher. Allen (2017) noted external validity as the extent to which study results from one study can be generalized in new settings, across groups, in new treatments, and time periods. Establishing external validity involves determining the extent to which the size or direction of a relationship remains consistent across contexts and samples (Allen, 2017). Internal validity, as shared by Frey (2018), pertains to the accuracy of statements made by the researcher specific to the causal relationship between the independent and dependent variables. Claims about internal validity are not based on the labels or descriptions given to variables but, rather, to the measurement of variables and study design (Frey, 2018).

Steps were taken in this research to minimize potential threats to validity. Specific steps included no personal contact with students or test administrators since all data were archival. This study was not longitudinal, nor did it involve treatment of the variables. Researcher bias was addressed through the use of archival data as the researcher worked in the participating school district and all data were provided to the researcher with all student identifiers removed. The researcher did not have access to any personally identifiable student data, nor the state assessment portal in which the data is currently stored, lessening the potential risk for researcher bias. The internal validity of this research is dependent on the reliability of instruments used.

Limitations

Limitations are common to all research and must be addressed. Ellis and Levy (2009) opined that limitations are potential weaknesses, which may include the study application or the study itself. The following were anticipated study limitations for this study:

1. Bias. Bias is a predisposition or partiality on the part of the researcher. Errors occurring in research that are systematically related to individuals or experimental conditions are considered biases that may cause the researcher to under or overestimate study measurements (Salkind, 2010a). Bias should be proactively addressed as it threatens study validity and generalizability (Salkind, 2010a). Researchers should manage potential bias by first acknowledging that it is common in social science research and remain open to interpretations of data that do not align with personal values and assumptions. Potential researcher bias exists for this study as the researcher is employed by the participating school district in a nontechnology-related role. Addressing bias may help to improve the researchers' ability to generalize study findings, and draw accurate causal conclusions (Salkind, 2010a). The limitation of bias was addressed using archival data to which the researcher would not have access until after receiving Nova Southeastern University and school district approval.

2. External validity. The extent to which study results can be generalized to individuals or situations outside of a given study (Frey, 2018). External validity of this study may be threatened if potential causal relationships are not generalizable outside the observed causal relationship to other settings (Frey, 2018). External validity was addressed through careful consideration of observed effects, and potential alternate explanations will be explained and included (Frey, 2018). This limitation is anticipated due to the study focusing on only one school district. However, the study utilized a G-Power analysis to determine the appropriate sample size for the study to help mitigate this limitation. In addition, the study sample will include all student scores from the target

school district that meet the criteria for participation in the study.

3. Fallacy of Homogeneity. Frey (2018) shared the fallacy of homogeneity occurs when the assumption that groups are internally homogeneous exists. The researcher noted this limitation as all groups are internally varied to a degree which influences the effect (Frey, 2018). The degree of the limitation of the homogeneity of variance was addressed in the Assumptions section. Additionally, the degree of this limitation is addressed by the assumption that the groups of low SES eighth-grade student SBAC summative scores and years of participation in a one-to-one laptop program are varied. The fallacy of homogeneity cannot be eliminated in this study as the groups of low SES eighth-grade student SBAC summative scores and years of participation in a one-to-one laptop program are varied. The fallacy of homogeneity must be recognized as it cannot be eliminated and should be addressed through explanations for each observed effect (Frey, 2018). Careful consideration of observed effects should be acknowledged, and potential alternate explanations should be explained and included (Frey, 2018). These mitigating techniques were utilized by the study.

4. Generalizability. This study focused on one grade level and utilizes one school district, creating the limitation of generalizability. Generalizability occurs in research when study results accurately reflect how results would present in real context if applied to a different sample or with the same variables operationalized in different ways (Frey, 2018). The parameters of one grade level across one school district may result in concerns regarding generalizability of potential conclusions that may be drawn from study results (Frey, 2018). Outcomes of the study should not be assumed applicable to populations of eighth-grade students in other school districts. To validate and expand upon potential conclusions first requires application in other environments and

populations (Frey, 2018). This limitation is anticipated. However, the study utilized a G-Power analysis to determine the appropriate sample size for the study to help mitigate this limitation. In addition, the study sample included all student scores from the target school district that meet the criteria for participation in the study.

5. Internal validity. Internal validity is the degree to which causal inferences between one or more independent variables and one or more dependent variables are justifiable (Frey, 2018). Internal validity of this study may be threatened in the event plausible alternative explanations are considered between hypothesized cause and effects (Frey, 2018). As suggested by Frey (2018), internal validity was addressed through careful consideration of observed effects, and potential alternate explanations were explained and included.

6. Post Hoc Fallacy. The post hoc fallacy occurs when the presumption is made that a relationship of variables in the study suggests a causal relationship (Frey, 2018). The post hoc fallacy is an error by the researcher in attributing causation, when no clear cause can be determined (Frey, 2018). The post hoc fallacy cannot be eliminated in this study as it is incorrect to assume that any statistical differences between low SES eighth-grade student SBAC summative scores based on years of participation in a one-to-one laptop program implies cause. The post hoc fallacy must be recognized as it cannot be eliminated and should be addressed through explanations for each observed effect (Frey, 2018). As recommended by Frey (2018), careful consideration of observed effects should be acknowledged, and potential alternate explanations should be explained and included.

Ethical Considerations

The ethical principles of the Belmont Report (McMillan, 2016) were taken into consideration in the development of this study and prior approval was requested from the university before data were collected. The school district's Director of Curriculum and Assessment was contacted and the required Proposals for Research Projects request to conduct research was completed and submitted to be approved and signed by a district official. The signature of the district official, once obtained, indicated approval has been granted by the district official to conduct the study and access granted to the district's low SES eighth-grade student ELA and mathematics SBAC summative achievement scale score data. Preexisting secondary archival data were used in this study, and direct contact with human participants did not occur, prompting a request for exempt status from the university (U.S. Department of Health and Human Services, 1979).

To protect the identity of students, teachers, the school district, and confidentiality of all school records, data for this study did not include names or student identification numbers and were used by the researcher for the purpose identified by this study (Anabo et al., 2019). The school district's Director of Curriculum and Assessment removed all student identifiers from the dataset and assigned randomly created student ID numbers prior to the release of data. The data file included an alphanumeric identifier for each student, eighth-grade assessment scale scores from the SBAC summative assessment for ELA and mathematics, and free and reduced lunch status. To address potential ethical concerns that might occur during the data collection process, data were kept in a secured safe in the researcher's home and were managed using two electronic sources, including a flash drive and backup external hard drive, and all hard copy documents were kept in an unlabeled folder. All digital data were stored in the researcher's password-protected computer with only the researcher knowing the password. All hard copy data were locked in a safe with only the researcher having the combination for the safe.

Chapter 4: Results

Introduction

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine if and to what extent there was a statistical difference, if any, between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district. The over-arching problem addressed by the study is the digital divide. According to van Dijk (2006), the digital divide is defined as unequal access to computers and the Internet based on economic status. The Chapter 2 literature review presented the gap in research evident in the literature for what is yet to be understood about the impacts of one-to-one programs on summative test data (Agasisti et al., 2020; Hazlett et al., 2019; Vu et al., 2019), and the effects of computer usage on the relationship between student SES and achievement (Bass, 2021; Chiao & Chiu, 2018).

This study examined differences in eighth-grade students' ELA and mathematics achievement based on years of participation in a Washington school district's one-to-one laptop program. Two research questions were addressed with a quantitative research methodology and a causal-comparative design. Data were collected for each variable from the participating school district's Washington Comprehensive Assessment Portal and were provided to the researcher, an employee of the target district, by the Director of Curriculum and Assessment at the participating school district. The nature of all data collected was secondary. The following research questions were established to guide this applied dissertation:

1. What is the statistical difference, if any, between 2016 eighth-grade ELA

achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated in the program for 3 years in a mid-sized, suburban school district in the state of Washington? The null hypothesis stated there is no statistically significant difference between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. The alternate hypothesis stated there is a statistically significant difference between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

2. What is the statistical difference, if any, between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington? The null hypothesis stated there is no statistically significant difference between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. The alternate hypothesis stated there is a statistically significant difference between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to-one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who

participated for 3 years in a mid-sized, suburban school district in the state of Washington.

Demographic Characteristics

Demographic characteristic information requested from the participating school district for the sample for the study included gender, free or reduced lunch status, and grade level. The demographic characteristics for the eighth-grade students of low SES during the 2015-2016 school year were 187 females and 189 males in the sample. The demographic characteristics for the eighth-grade students of low SES during the 2017-2018 school year were 167 females and 186 males in the sample. All eighth-grade students of low SES were included with no exclusion based on age, gender, ethnicity, or other demographic marker. The purposive sampling strategy was utilized to select the sample for the study as all 2016 and 2018 eighth-grade students of low SES in one Washington school district for whom SBAC summative ELA and/or mathematics scale scores existed. The unit of analysis was eighth-grade students.

The target population for the study was all eighth-grade students of low SES who participated in the one-to-one laptop program in the participating school district in Washington from 2015 to 2018. The population from which the sample was drawn was all 2016 and 2018 eighth-grade students of low SES, with a valid SBAC summative assessment ELA and/or mathematics scale score in the target Washington school district, who also participated in the one-to-one laptop program during the designated years. The total sample used for the analysis after non-tested and outliers were removed from 2016 eighth-grade ELA SBAC summative achievement scale scores for students of low SES in Group 1 was 338. The Group 2 sample was 328 used for the analysis after non-tested and outliers were removed from 2018 eighth-grade ELA SBAC summative achievement scale scores for students of low SES. Group 3 included a sample size of 341 used for the analysis after non-tested and outliers were removed from 2016 eighth-grade mathematics SBAC summative achievement scale scores for students of low SES. Group 4 included a sample size of 326 used for the analysis after non-tested and outliers were removed from 2018 eighth-grade mathematics SBAC summative achievement scale scores for students of low SES. Table 3 illustrates demographic data based on gender.

Table 3

Sample Demographics

Item	2016	2018
Male	189	186
Female	187	167
Male English scores	167	175
Female English scores	169	153
Male math scores	170	173
Female math scores	171	153

Data Analysis

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine if and to what extent there was a statistical difference, if any, between 2016 eighth-grade ELA and mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district. It is not known if and to what extent a difference exists if any, between 2016 eighth-grade ELA and mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district.

The collected SBAC summative scale score data were used to answer the two research questions for the study. The research questions investigated if there was a statistically significant difference between eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Group 1 included SBAC ELA scale scores from 167 male students, and 169 female students. Group 2 included SBAC ELA scale scores from 175 male students and 153 female students. Group 3 included SBAC mathematics scale scores from 170 male students and 171 female students. Group 4 included SBAC mathematics scale scores from 173 male students and 153 female students. The first research question considered 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated in the program for 3 years in a mid-sized, suburban school district in the state of Washington. Groups 1 and 2 were compared to address this question. The second research question considered 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. Groups 3 and 4 were compared to address this question.

Results for each research question and whether the null hypotheses were accepted or rejected are presented in the next section. Data analysis procedures included a descriptive and inferential statistical analysis using an independent-samples *t* test to test the research hypotheses for each research question by determining the statistical difference between groups at the .05 level of significance. Descriptive statistics included the number of scale scores for each of the ELA and mathematics groups, and the mean scale scores for each of the groups. This section includes a restatement of each research question and study findings. To examine the problem of the research study, two research questions and associated hypotheses were presented.

Results for Research Question 1

What is the statistical difference, if any, between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district? The hypotheses for the first research question were as follows:

1. There is no statistically significant difference between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

2. There is a statistically significant difference between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

The SBAC ELA scale score mean for Group 1 was 2569.82, the standard deviation was 111.620, and the standard error mean was 6.089. The SBAC ELA scale score mean for Group 2 was 2526.36, the standard deviation was 108.235, and the standard error mean was 5.976. Assuming that the variances were equal, the degree of freedom was 662, and the independent-samples *t* test generated a *p* value that was < .001, which was smaller than .05 level of significance, resulting in a statistically significant difference between the two groups. The results of the *t* test were as follows: $t = 5.092$, $df = 662$, $p < .001$.

The Levene's Test for Equality of Variances was run to compare the variances between the two groups because it was assumed that the variances were equal. The Levene's Test determined that it was statistically supported. In this case, the *p* value was .383, which was greater than the .05 level of significance and yielded no significant difference between the variances. Given equal variances was correctly assumed, the *t* statistic was 5.092 with a mean difference of 43.462. The Cohen's *d* test results yielded the difference in terms of standard deviation units, which was .395 between the two groups. Based on the results of the independent-samples *t* test, generating a *p* value that was statistically significant at .383, and the Levene's Test determining that it was statistically supported, the null hypothesis was rejected and the alternate hypothesis was accepted. The SBAC ELA scale score descriptive analysis for Group 1 indicated the following: *M* = 2569.82, *SD* = 111.620, *SEM* = 6.089. The SBAC ELA scale score descriptive analysis for Group 2 indicated the following: *M* = 2526.36, *SD* = 108.235, *SEM* = 5.976.

Results for Research Question 2

What is the statistical difference, if any, between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district? The hypotheses for the second research question were as follows:

1. There is no statistically significant difference between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

2. There is a statistically significant difference between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington.

The SBAC mathematics scale score mean for Group 3 was 2548.18, the standard deviation was 143.132, and the standard error mean was 7.751. The SBAC mathematics scale score mean for Group 4 was 2504.26, the standard deviation was 112.969, and the standard error mean was 6.257. Assuming that the variances were equal, the degree of freedom was 665, and the independent-samples *t* test generated a *p* value that was < .001, which was smaller than .05 level of significance, indicating a statistically significant difference between the two groups. The results of the *t* test were as follows: $t = 4.385$, $df = 665$, $p < .001$.

The Levene's Test for Equality of Variances was run to compare the variances between the two groups because it was assumed that the variances were equal. The Levene's Test determined that it was statistically supported. In this case it was < .001, which was less than the .05 level of significance and indicated no significant difference between the variances. Given equal variances was correctly assumed, the *t* statistic was 4.385 with a mean difference of 43.912. The Cohen's *d* test results yielded the difference in terms of standard deviation units, which was .340 between the two groups. Based on the results of the independent-samples t test generating a p value that was statistically significant at $< .001$, and the Levene's Test determining that it was statistically supported, the null hypothesis was rejected and the alternate hypothesis was accepted. The SBAC mathematics scale score descriptive analysis for Group 3 indicated the following: $M = 2548.18$, $SD = 143.132$, and $SEM = 7.751$. For Group 4, the results were as follows: $M = 2504.26$, $SD = 112.969$, and $SEM = 6.257$.

Summary

There were two research questions and four hypotheses in this study. An independent-samples t test with an appropriate confidence level of 95% was executed. The independent-samples t test was used to determine the extent to which a statistical difference existed between groups (Laerd Statistics, 2023d). For the first research question, a statistically significant difference was found between groups. Group 1 consisted of 2016 eighth-grade ELA achievement scores for students of low SES who participated for 1 year in a one-to one laptop program, and Group 2 consisted of 2018 eighth-grade ELA achievement scores for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. Based on the t-test analysis for Research Question 1, the null hypothesis was rejected and the alternate hypothesis was accepted.

For the second research question, a statistically significant difference was found between groups. Group 3 consisted of 2016 eighth-grade mathematics achievement scores for students of low SES who participated for 1 year in a one-to one laptop program, and Group 4 consisted of 2018 eighth-grade mathematics achievement scores for students of low SES who participated for 3 years in a mid-sized, suburban school district in the state of Washington. Based on the *t*-test analysis for Research Question 2, the null hypothesis was rejected and the alternate hypothesis was accepted. The next and final chapter contains information pertaining to the study's findings, including interpretation, context, and implications. In addition, limitations of the study and future research directions are presented.

Chapter 5: Discussion

Introduction

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Connectivism, which provided the theoretical foundation for the study, is a learning theory that explains how technologies have created new opportunities for people to learn and share information across the World Wide Web and among individuals (Siemens, 2005). A gap was identified in the research literature highlighting the need for studies to investigate whether school related ICT use impacts student achievement (Bixler, 2019; Karlsson, 2020; Vu et al., 2019; Weber & Becker, 2019).

The overarching problem addressed by this study was the digital divide. The digital divide is defined as unequal access to computers and the Internet based on economic status (van Dijk, 2006). Van Deursen and van Dijk (2019) opined that the digital divide is a societal issue. Talaee and Noroozi (2019) noted that students of low-income are more likely to experience the effects of the digital divide. For students of low-income, hurdles like completing homework in a digital environment may impossible for some, and extremely difficult for others (Anderson & Perrin, 2018). The impact of one-to-one programs on the achievement of students of low SES needs further exploration as these students may be victims of the problem of the digital divide (Chiao & Chiu, 2018). In addition, the research on the topic of the digital divide as it impacts student achievement, needs to be better understood (Chiao & Chiu, 2018; Weber & Becker, 2019). This study provides a source of information to school districts interested in examining their practice of achieving equity in technology integration to decrease the digital divide.

COVID-19 has compounded educational disparities, thus broadening existing achievement gaps between students of high and low SES (Reza, 2020). In addition, when considering access to an ICT, minority students and students of color frequently experience barriers to participation in online learning (Reza, 2020). School districts are working to address technology related barriers; however, many students continue to be impacted (Reza, 2020). The study provided information relative to the digital divide. This information helped to address an identified gap in research by determining the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Chapter 5 presents a summary of findings. In addition, an interpretation, context, and implications of the study's findings will be presented. Finally, limitations of the study and future research directions will be discussed.

Summary of Findings

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. A quantitative methodology with a causal-comparative design was selected to answer the research questions. Secondary data were retrieved for all 2016 and 2018 eighth-grade students of low SES, with a valid SBAC summative assessment ELA and/or mathematics scale score in the target Washington school district, who also participated in the one-to-one laptop program during the designated years. The total sample used for the analysis after non-tested and outliers were removed from 2016 eighth-grade ELA SBAC summative achievement scale scores for students of low SES in Group 1 was 338. The Group 2 sample was 328 used for the analysis after non-tested and outliers were removed from 2018 eighth-grade ELA SBAC summative achievement scale scores for students of low SES. Group 3 included a sample size of 341 used for the analysis after non-tested and outliers were removed from 2016 eighth-grade mathematics SBAC summative achievement scale scores for students of low SES. Group 4 included a sample size of 326 used for the analysis after non-tested and outliers were removed from 2018 eighth-grade mathematics SBAC summative achievement scale scores for students of low SES. Data analysis procedures included a descriptive statistical analysis for the sample and scale score data. An inferential statistical analysis utilizing an independent-samples *t* test to test the research hypotheses for each research question was utilized to determine the statistical difference between groups at the .05 level of significance.

Research Question 1 asked the following: What is the statistical difference, if any, between 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district? The finding for the first research question was that a statistically significant difference was found between groups. The independent-samples *t* test generated a p value that was $< .001$. Therefore, the null hypothesis was rejected and the alternate hypothesis was accepted.

Research Question 2 asked the following: What is the statistical difference, if any, between 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program and 2018 eighth-grade students of low SES who participated for 3 years in a Washington school district? The finding for the second research question was that a statistically significant difference was found between groups. The independent-samples *t* test generated a *p* value that was < .001. Therefore, the null hypothesis was rejected and the alternate hypothesis was accepted.

Interpretation of Findings

One meaningful aspect of the information and findings produced by this study was that several gaps identified in the research were addressed. This study addressed a gap in the research identified by Rizk and Davies (2021), indicating the need for information on how digital technology could foster achievement. This study also addressed a gap in the research, noted by Bass (2021), as a need for information related to the effect of technology investments on student achievement. Additionally, this study addressed a gap in the research identified by Bixler (2019), as a need for information on the achievement of students of low SES in one-to-one laptop environments. Weber and Becker (2019) identified the need for long-term studies to investigate whether use of the Internet connected devices for school-related activities was connected with higher educational achievement and further success.

This study's findings serve to address the gap in research identified by Rizk and Davies (2021) and Bixler (2019) by examining if a one-to-one laptop program could impact student achievement. The findings also help to address the gap in research presented by Bass (2021) by providing information related to the effect of investments in one-to-one laptop programs on student achievement. In addition, this study addressed the gap in research noted by Weber and Becker (2019) of the need for long-term studies as this study analyzed educational achievement data from 1 year and 3 years.

This study provides important meaning for society as many schools worldwide, include students of low SES. This study provides insight to school districts wanting to decrease the digital divide by providing equitable, one-to-one laptop access to students of low SES and greater understanding of the potential impacts on student achievement in schools that provide one-to-one laptop programs for students. School districts may utilize this study's results in part, to make financial decisions about investing in one-to-one laptop programs for students of low SES.

The findings of the study indicated a statistically significant difference in both ELA and mathematics achievement for eighth-grade students of low SES who participated in the one-to-one laptop program for 1 year compared to those who participated for 3 years. Both ELA and mathematics scores were higher for the groups that participated for 3 years. This result was expected based on information in the research literature. According to Green (2020), students of low SES are less likely than non-low SES peers to have time on, or access to a computer at home, harming their ability to do schoolwork and achieve academically. Findings from Bass' (2021) study show that additional technology funding significantly increased the academic achievement of elementary and middle school students of low SES in math and English. Kay and Schellenberg (2019) noted that students in one-to-one programs had better quality work, were better organized, and were more productive than students not in one-to-one programs. Reisdorf et al. (2020) found that college freshmen who owned a laptop had significantly higher academic achievement than college freshmen who did not own a laptop. A meaning of this information is that a longer time period with greater access to technology such as laptop computers can produce higher achievement for students of low SES.

A second meaning derived from the findings of this study is that the problem of the digital divide can be addressed by providing technology to individuals of low SES. The digital divide is defined as unequal access to computers and the Internet based on economic status (van Dijk, 2006). Participants in the current study were students of low SES. Talaee and Noroozi (2019) noted poverty as the dividing line between those with ubiquitous access to technology and those without. Students with unequal access to quality technology devices such as students of low SES, might be at more of a disadvantage than non-low SES students when one-to-one device programs are not in place (Kay & Schellenberg, 2019). As indicated by the findings for the current study, addressing the digital divide by providing greater access to technology, such as laptop computers to students of low SES, can lead to higher achievement levels for those students. This result was expected based on the research literature. According to Hampton et al. (2020), students without home ICT access have lower grades overall in comparison to more affluent peers, specifically in the core subjects of ELA, social studies and history. Additionally, Muñiz (2021) and Andrew et al. (2020) shared that the COVID-19 pandemic deepened the digital divide as many students of low SES lacked devices creating a barrier to participating in learning, significantly impacting achievement. Investing in equitable education practices early on for students of low SES yields academic increases indicating a high return on investment (Organization for Economic Cooperation and Development, 2012). For example, 15-year-old students of low SES are 2.37 times more likely to score lower on standardized reading assessments than non-low SES peers (Organization for Economic Cooperation and Development, 2012). Therefore, the findings of this study support that the problem of the digital divide may be addressed by providing technology to individuals of low SES.

A third meaning that could be derived from the findings of the current study is that addressing the problem of the digital divide by providing greater access to technology for students of low SES provides an opportunity for valuable return on investment by school districts. According to Bass (2021), increases in technology spending at schools with greater than 40% free and reduced lunch status overall significantly increased the percentage of students scoring at or above proficiency in both English and mathematics. Additionally, Bass opined that additional technology spending of $50 per student on software and hardware can significantly increase the achievement of students of low SES at the middle school level. The findings of the current study further support these ideas presented by Bass. The district's investment in the one-to-one laptop program yielded higher achievement levels for students of low SES that participated in the program for 3 years compared to those who participated for 1 year. This result was expected and supported by information provided in the research literature. Machin et al. (2007) opined that investments in ICT for populations of low SES at the elementary school level results in increased academic performance in both English and Science. A study by Reisdorf et al. (2020) provided that students who owned a laptop had significantly higher academic achievement than students who did not own a laptop. According to Kay and Schellenberg (2019), higher student achievement represented a positive return on investment in technology by a school district, addressing the digital divide. As a result, this study's findings support that providing greater access to technology for students of low SES may provide an opportunity for valuable return on investment by school districts.

Expected and Unexpected Results

The rejection of the null hypothesis and acceptance of the alternate hypothesis for each of the two research questions dealing with both ELA and mathematics achievement was expected by the researcher. Expected results were that a statistically significant difference would exist in 2018 eighth-grade ELA achievement for students of low SES who participated for 3 years in a one-to one laptop program, compared to 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program. In addition, expected results were that a statistically significant difference would exist in 2018 eighth-grade mathematics achievement for students of low SES who participated for 3 years in a one-to one laptop program, compared to 2016 eighth-grade mathematics achievement for students of low SES who participated for 1 year in a one-to one laptop program. No unexpected results surfaced during the data analysis process. While results were expected, the researcher worked to maintain an unbiased perspective during the research process.

Context of Findings

This section of Chapter 5 provides a review of findings in current research literature on the topic of the digital divide as they relate to the context of this study's findings. This study examined differences in eighth-grade students' ELA and mathematics achievement based on years of participation in a Washington school district's one-to-one laptop program. According to Agasisti et al. (2020), an urgent need exists in the research literature to discuss the effects of computers on improving student achievement. Since the 1980s, the debate over whether computers had positive effects on test scores and graduation rates has been active (Agasisti et al., 2020). The value computers bring to the classroom has rarely been challenged (Mora et al., 2018). However, the question of return on investment remained in the economics literature specifically, as there was no consensus about the potential link between computers and achievement (Mora et al., 2018). This may have given school districts cause for pause when considering increases in their technology spending.

Increasing spending on computers in educational settings may increase equity across socioeconomic lines (Scherer & Siddiq, 2019), but may not increase achievement (Mora et al., 2018). Understanding the impacts of computers on achievement was relative to the overall dissertation topic as current research on computers and achievement was pertinent to the dissertation topic of achievement differences based on years of participation in a one-to-one laptop program. Current research literature provided diverse perspectives and study results specific to computers and achievement (Agasisti et al., 2020; Hazlett et al., 2019; Kert et al., 2019; Mora et al., 2018; Nkemakolam et al., 2018; Robinson et al., 2018; Vu et al., 2019; Weber & Becker, 2019).

Many studies noted that computers may distract students and may even be harmful to learning, while others opined that computers positively impacted student achievement (Coşar & Özdemir, 2020). Mora et al. (2018) stated that, despite findings supporting the similarities and differences between research studies they reviewed, there was no clear consensus on whether the implementation of computers in the classroom favorably or unfavorably impacted student achievement (Mora et al., 2018). A review of results from the literature revealed that empirical results on the impact of one-to-one computer programs on student achievement are mixed (Mora et al., 2018). The current study addressed the problem of the digital divide. The study provided additional information on this topic and addressed gaps in the literature as identified by researchers such as Vu et al. (2019). Vu et al. documented the need for future research to measure the academic impacts of one-to-one programs on students' academic performances on standardized tests. Similarities and differences from findings published in the research literature are discussed in this section to provide context to this study's findings.

This research study utilized a causal-comparative research design. Results of this study are that students of low SES who participated for 3 years in a one-to-one laptop program, had higher ELA and mathematics achievement than students of low SES who participated for 1 year in a one-to-one laptop program. Similar findings are documented in the research literature. Robinson et al. (2018) conducted a qualitative research study with a case study design. The authors examined the effects of digital inequality on student achievement of high school seniors of low SES. The total study population was 1,015 predominantly students of low SES. The total sample size was 972 high school seniors graduating from a large public high school in the United States. Robinson et al. sought to understand the following: If the duration of computer use by students of low SES increased, would those students' grade point averages also increase? The study's findings showed that a longer duration of computer use was positively correlated with academic achievement for high school seniors of low SES. Seniors with longer exposure to computers had higher grade point averages compared to high school seniors of low SES with a shorter duration of computer experience. Robinson et al. noted that this correlation left no question that the digital divide could be highly consequential to the achievement of students of low SES.

The study by Robinson et al. (2018) shared similarities with this study as both considered achievement impacts of the digital divide and shared similar findings supporting the positive impacts of computers on achievement. Additional similarities included that the study populations were similar as both populations included U.S. students of low SES in upper grades. The studies differed in methodology, design, and sample size. The study by Robinson et al. included 972 high school seniors, whereas this study included approximately 376 eighth-grade students in 2016 and 353 in 2018. Additionally, this study focused on summative SBAC ELA and mathematics achievement data, whereas the study by Robinson et al. focused on grade point average.

Additionally, Reisdorf et al. (2020) published research on the impacts of laptops on academic achievement. In spring 2017, Michigan State University required that all undergraduate students have an Internet-connected laptop. The authors utilized a quantitative descriptive design to answer questions of how laptop ownership affected achievement. The study population was 8,306 college freshmen, and the total sample size was 4,170. Study findings were that college freshmen that did not own a laptop had substantially lower academic performance than students who owned a laptop. The findings in the study by Reisdorf et al. were similar to the findings in this study as both studies analyzed student achievement data. Differences between the study by Reisdorf et al. and this study included the age of the students, sample sizes, geographical location, methodology, and design. While the findings for both studies pertained to laptops and achievement, the Reisdorf et al. study focused on ownership versus non-ownership and this study focused on the length of time as 1 year versus 3 years in a one-to-one laptop program.

Kert et al. (2019) conducted a mixed methods study with a sequential explanatory design examining teacher and student perceptions of academic achievement in a computer science program. The study population was middle level students, and the sample included 162 students aged 10 and 12 years old from different cities across Turkey. Participants took pretests and posttests measuring academic performance. The study's findings showed that computer-based instruction positively affected student achievement on post-tests. In addition, teacher feedback aligned with the post-test findings that achievement was positively affected. This study's findings aligned with the findings in the study by Kert et al. that achievement may be positively affected by computers. The Kert et al. study sample was similar to this study as the participants were similar in age. The geographical location and study populations differed as the Kert et al. study population was from Turkey, and this study's population was from the United States. The Kert et al. sample size of 162 was smaller than the sample size of approximately 376 eighth-grade students in 2016 and 353 in 2018 in this study. An additional difference was that the Kert et al. study considered the use of computers for computer science achievement and this study analyzed ELA and mathematics achievement data from participants in a one-to-one laptop program for 1 year vs. 3 years.

Research by Campbell et al. (2022) examined the changes in fifth-grade overall reading achievement scores in a computer adaptive reading program using a quantitative methodology with a quasi-experimental design. The Campbell et al. study population included 14,525 fifth graders from 14 school districts in a southeastern state. The sample size of 900 students from 108 different schools across eight districts in a southeastern state was determined using propensity score matching. Findings from the Campbell et al. study concluded that students utilizing a computer-adaptive reading program had statistically significant higher academic overall reading gains than students who did not utilize a computer-adaptive reading program. Similarities between the Campbell et al. study and this study are the use of the quantitative methodology and the examination of the impacts of computers on student achievement. In both studies, achievement was statistically significantly higher for students participating in computer programs. Differences between the Campbell et al. study and this study are the Campbell et al. study analyzed pretest and posttest scores, whereas this study utilized summative SBAC scores.

Additionally, in comparison, the Campbell et al. study population was much larger and encompassed multiple school districts. The sample size in the Campbell et al. study was also larger and included all fifth-grade students, regardless of SES status. An additional difference was the Campbell et al. fifth-grade students were younger than the eighth-grade students in this study.

Research similar to this study that found no statistically significant difference in achievement related to computer use exists in the literature. In a 2020 study by Yanguas, the author found no positive effect on test scores related to primary and middle school student participation in a one-to-one program in Uruguay. Karlsson's (2020) research focused on primary school students, finding mostly no or weak evidence that computers increase achievement, especially in the areas of mathematics and science. Hull and Duch (2019) researched the impacts of a one-to-one laptop program on achievement. The authors found short term impacts of the one-to-one program on mathematics scores as not statistically significant, and only a small effect appeared in the medium term. Hull and Duch found similar results for reading scores with no statistically significant impact in the short term, and mixed evidence for improvement in the medium term. These studies serve to demonstrate that results of impacts of technology on student achievement continue to be uncertain. However, the current study demonstrates a statistically significant difference in ELA and mathematics achievement for students participating in a one-to-one laptop program for 3 years compared to those participating for 1 year in the target school district.

Implications of Findings

The foundation for this study was determined by a thorough review of the research on one-to-one laptop programs and student achievement. Ensuring equitable access to technology is especially important for students of low SES as they often lag behind in computer and Internet access at home (Hull & Duch, 2019). Schools must prepare students for the world of work which includes the ability to adapt and utilize technology in order for the economy to flourish (Hull & Duch, 2019). Therefore, a theory relevant to learning, the digital age, and the problem space of the digital divide was essential as a foundation for the study. The theoretical foundation selected for the study was Siemens' (2005) Connectivism Theory. The findings of the study were that a statistically significant difference existed in both ELA and mathematics achievement for eighth-grade students of low SES who participated in the one-to-one laptop program for 1 year compared to those who participated for 3 years. Both ELA and mathematics scores were higher for the groups that participated for 3 years. These findings have multiple implications.

Theoretical Implications

The theory that undergirded this study was Siemens' (2005) Connectivism Theory. Connectivism is a learning theory specific to the digital age integrating principles from chaos, network, complexity, and self-organization theories (Siemens, 2005). Siemens described connectivism as a learning theory specially designed to address the unique ways in which learning happens in contemporary classrooms. By implementing a one-to-one laptop program for all students in the participating school district, the unique ways in which learning can happen was available to all students regardless of socioeconomic status. This study focused on ELA and mathematics summative assessment achievement outcomes between groups of eighth-grade students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. Soomro et al. (2020) opined that the digital divide is an important issue to be addressed for social justice in the 21st century. This study focused on students of low SES and applied Connectivism Theory to address the learning happening in the one-to-one computer program. Research has noted that connectivism supports a significant trend in learning where technology supports a multitude of learning processes in the modern classroom. A contribution of this study was that it provided implications related to Connectivism Theory.

According to Siemens (2005), connectivism is a learning theory that explains how technologies have created new opportunities for people to learn and share information across the World Wide Web and among individuals. The results of this study provided information on statistical differences in learning based on access to technology, which aligned with the theory of connectivism. These results provided additional information on the eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. This study and the study's results provided information aligned with the tenet of Connectivism Theory related to how technologies have created new opportunities for people to learn. The implication is that the current study's results support Connectivism Theory and add credence to the theory for use in further research. Use of Connectivism Theory as a foundation for the current study provides an example of implications for the theory in the area of education and student learning.

Research Implications

The foundation for this study began with reviewing the literature on the digital divide and the impacts of one-to-one programs on achievement of students of low SES. The digital divide is linked to differences in reading and mathematics achievement levels for school-aged children across the United States (Jacobsen, 2020). This study sought to address the problem of the digital divide by comparing differences of groups of eighth-grade students of low SES based on the length of time participating in a one-to-one laptop program. The study's findings have implications for research related to potential impacts of providing equitable, one-to-one ICT access on student achievement. Meyer (2017) opined a need for research to assess potential impacts of comparing standardized test scores at the same school before and after a one-to-one laptop intervention. Additionally, Vu et al. (2019) opined that research was needed to conduct a formal evaluation of a one-to-one laptop program, evaluating students' academic performance on summative tests.

Further, Bass (2021) shared that a negligible number of studies have examined the effect of technology investments on student achievement. This study's findings that students of low SES who participate for 3 years in a one-to-one laptop program compared to 1 year show a statistically significant difference in summative ELA and mathematics SBAC scores. An implication of this study's findings for research is that the study and resulting findings addressed the needs for research identified by Meyer (2017), Vu et al. (2019), and Bass.

Research evaluating the impacts of computer integration programs have yielded mixed results (Hull & Duch, 2019). Hull and Duch (2019) share that many evaluations of one-to-one programs in the literature have serious methodological concerns. This research utilized a quantitative methodology to analyze archival data to determine statistically significant differences. Whitehead (2019) noted that the quantitative methodology is appropriate for research requiring measurement and statistical analysis of numerical data. The rationale behind the decision to select a quantitative methodology is that, according to Bass (2021), few quantitative studies have examined the effect of technology investments on student achievement. Therefore, a research implication for the current study is that it addresses the concern expressed by Hull and Duch (2019) related to studies on the topic having methodological concerns.

Karlsson (2020) noted the need for further research on the effect of computer use beyond fourth grade on achievement when computers are implemented on a larger scale. This research analyzed eighth-grade achievement data from all eighth-grade students in one school district. An additional recommendation for research was to analyze achievement of students in poverty (Bass, 2021) and in one-to-one programs (Bixler, 2019). The current study addressed research gaps needing to be addressed to further digital divide research pertaining to academic achievement on summative tests, students of low SES, and one-to-one laptop programs.

The problem of the digital divide continues creating the need for research on this topic. A growing economic divide increases the potential for a greater digital divide among students, putting even more at risk of falling further behind (Jacobsen, 2020). In addition, Soria and Horgos (2020) opined that students of low SES are significantly more likely than non-low SES students to lack necessary technology for learning. A research implication for the current study's findings is that the study added information to the research literature on the topic of the digital divide and provides a reference for future researchers on this topic.

Practical Implications

Practical implications of this study's findings are that one-to-one laptop programs may positively impact the summative assessment achievement outcomes of eighth-grade students of low SES beyond the current study. School districts with student populations that include students of low SES may consider implementing one-to-one laptop programs to decrease the digital divide and increase summative assessment scores of students of low SES. Backes and Cowan (2019) noted that computer-based assessments were rapidly gaining in popularity and implementation. Specific to students of low SES, Allen et al. (2020) opined that Black students in low SES areas of Toronto were impacted by lack of technological access to learning stemming from COVID-19 and remote learning. In addition, with respect to the impacts of COVID-19 and computers in learning, results of this study also provided important information to school decision makers on the return on investment impacts of one-to-one computer programs on state testing student achievement. While this study examined only ELA and mathematics summative assessment achievement outcomes between groups of eighth-grade students of low SES established based on years of participation in a Washington school district’s one-to-one laptop program, implications of this research may be applied in other schools with students of low SES. Therefore, practical implications of this study were that one-to-one laptop programs should be considered by school districts wanting to reduce the digital divide, and increase achievement for students of low SES.

Practical implications of this study’s results may serve to inform school district leaders about the potential to reduce costs associated with the digital divide. Copious amounts of prior research on the efficacy of strategies to increase achievement of low-performing students exists (Pan & Sass, 2020). Pan and Sass (2020) opined that extending the school day or implementing summer school brings financial impacts to school districts upwards of $800 to $1,100 per student. Struggling students are often enrolled in remedial education programs such as increased instructional time, increasing the intensity of instruction through tutoring and teacher-student matching which come with significant costs to school districts (Pan & Sass, 2020). Remedial education services may require reallocation of school funds and staff time to provide remedial instruction that could have been allocated elsewhere (Van Orden, 2020). Therefore, taxpayers may be paying double for students of low SES to learn foundational concepts in core subjects in remedial classes (Van Orden, 2020). Differences in ELA and mathematics proficiency levels are connected to digital and economic divides (Jacobsen, 2020). Practical implications of this study's results are that providing one-to-one computers to students of low SES may decrease the digital divide, and increase achievement. Implementing a one-to-one laptop program may be considered by school districts seeking to increase achievement in ELA and mathematics of students of low SES and reduce the differences in proficiency between low SES and non-low SES students. Implementation of a one-to-one laptop program could have the practical implications of fewer students requiring remediation programs, thus resulting in potential cost savings for school districts.

Limitations of the Study

This study was a nonexperimental quantitative causal-comparative study using an independent-samples *t* test to determine if and to what extent differences in ELA and mathematics achievement existed between groups established based on years of participation in a Washington school district's one-to-one laptop computer program. Limitations are potential weaknesses, which may include the study application, or the study itself (Ellis & Levy, 2009). Limitations of a study may cause threats to internal and or external validity (Laerd Statistics, 2023a, 2023e). Limitations specific to the current study include both internal and external threats to validity that may have impacted the study's results. The study limitations for this study, how the limitation was addressed, and information as to the limitation on the study's implementation or findings are outlined below.

A limitation of the current study was generalizability. Generalizability is the degree and scope that study results can be generalized outside of a specific study (Frey, 2018). The study's results are specific to the eighth-grade students of low SES in one Washington school district; creating a potential threat to the external validity of these study results. As shared by Ercikan and Roth (2014), findings from one geographical region cannot be extrapolated to all. School districts across Washington state include diverse demographics. The limitation related to use of only one grade level in one school district and the limitation implications related to generalizability were anticipated. To address this limitation, the study utilized a G*Power analysis to determine the appropriate sample size for the study, which required a total sample size of 210 with 105 in each group. In addition, the study sample included all student scores from the target school district that met the criteria for participation in the study. The researcher worked with the school district's Director of Curriculum and Assessment to confirm that the sample size required by the G*Power analysis was met prior to proceeding with the study in an effort to minimize the limitation. However, since the study was conducted in only one school district, generalizability may be limited to similar school districts in similar settings.

A second limitation included the threat to internal validity in that that there were many contributing factors that could potentially impact the achievement of students of low SES. This study focused solely on a one-to-one laptop program as the potential contributing factor impacting achievement. To limit the impact of this limitation a causal-comparative study design was implemented. A causal-comparative design affords researchers the ability to determine the potential cause for a resulting effect (Frey, 2018). Frey (2018) also noted that the independent variable is categorical, and two or more groups are compared to test for causality when the researcher seeks to answer research questions that compare differences between groups. The current study compared achievement differences between two groups for each of two research questions, finding that statistically significant differences existed between groups. It is acknowledged that many factors affect achievement and this is a limitation to be considered when interpreting the findings of the current study. The use of a sound methodology and design were utilized to mitigate this limitation.

A third limitation and a threat to external validity was the potential limitations of bias. The limitation related to potential limitations of bias was anticipated. To address this limitation, the researcher was not involved in the data collection or interpretation process. In addition, deidentified secondary archival data collected previously via the Washington Comprehensive Assessment Portal were provided to the researcher by the Director of Curriculum and Assessment for the participating school district. A quantitative research methodology and a causal-comparative design were utilized to analyze the data to greatly decrease the potential for research bias.

A fourth limitation of the study was the threat to internal validity due to the fallacy of homogeneity. Frey (2018) shared the fallacy of homogeneity occurs when the assumption that groups are internally homogeneous exists. The limitation of the fallacy of homogeneity was anticipated. To address this limitation, the Levene’s test for homogeneity was run to compare the variances between the two groups because it was assumed that the variances were equal. The Levene's test determined that the results of the independent-samples *t* test were statistically supported. The *p* value was .383, which was greater than the .05 level of significance, which yielded no significant difference between the variances. Given equal variances was correctly assumed, the *t* statistic was 5.092 with a mean difference of 43.462. The Cohen's *d* test results yielded the difference in terms of standard deviation units, which was .395 between the two groups. Based on the results of the independent-samples *t* test generating a *p* value that was statistically significant at .383, and the Levene's test determining that it was statistically supported, the null hypothesis was rejected and the alternate hypothesis was accepted. Therefore, the limitation of fallacy of homogeneity was addressed and the study's findings were that a statistically significant difference existed between groups.

A fifth limitation of this study was the potential threat to internal validly due to student familiarity with online testing. Student participation in the one-to-one laptop program for 3 years may have contributed to the increases in ELA and mathematics achievement observed over the scores of students that participated for 1 year. Internal validity is the degree to which causal inferences between one or more independent variables and one or more dependent variables are justifiable (Frey, 2018). The independent variable for the study was years of participation in a Washington school district's one-to-one laptop program. The two categorically independent groups were 1-year participation as 2016 and 3 years of participation as 2018. Dependent variables for the study were ELA achievement and mathematics achievement based on 2016 and 2018 ELA and mathematics SBAC summative assessments for students of low SES.

Frey (2018) opined the limitation of internal validity may be addressed through careful consideration of observed effects and inclusion of potential alternate explanations. In an effort to minimize this limitation, observed effects were considered as possible differences between groups. It was determined that a possible explanation for the differences between groups may be contributed to types of instruction or curriculum that were implemented during years of participation in the one-to-one laptop program versus one-year participation. For example, the difference in achievement in the group that participated for 3 years may be due to changes in instruction or curriculum of which the researcher was not made aware. The limitation related to student familiarity with online testing and the limitation implications related to the potential threat to internal validity was anticipated and potential explanations presented. The limitation of internal validity did not impact the study's implementation or findings. Careful consideration of observed effects and inclusion of potential alternate explanations were utilized to mitigate this limitation.

Future Research Directions

The purpose of this quantitative, nonexperimental, causal-comparative study was to determine the extent to which a statistical difference existed in eighth-grade ELA and mathematics summative assessment achievement outcomes between groups of students of low SES established based on years of participation in a Washington school district's one-to-one laptop program. In this section, recommendations for future research are presented. These recommendations, if acted upon, could provide additional information related to this study's topic. This study's findings were that a statistically significant difference existed in 2018 eighth-grade ELA and mathematics achievement for students of low SES who participated for 3 years in a one-to one laptop program, as compared to 2016 eighth-grade ELA achievement for students of low SES who participated for 1 year in a one-to one laptop program. This study's findings support the following recommendations for future research.

Future research could explore this topic using a qualitative methodology. Qualitative research includes exploration, observations, interviews, perspectives, thoughts, feelings, interpretations and beliefs (Arghode, 2012; Sarma, 2015). A recommendation for future research is a qualitative study seeking to understand the online high stakes testing experiences of high school graduates of low SES previously involved in a one-to-one laptop program. Understanding lived experiences helps further research by discovering trends and themes that can be applied in other areas (Park & Park, 2016). Understanding the thoughts, feelings, and perspectives of high school graduates of low SES that had previously participated in a one-to-one laptop program would provide additional understanding of the human perspective of one-to-one programs for students of low SES beyond the quantitative documentation of test scores related to achievement.

This study focused on the summative assessment achievement outcomes of eighth-grade students of low SES from one school district. Therefore, future research focusing on the summative assessment achievement outcomes of eighth-grade students of low SES from different school districts would be beneficial. Understanding the assessment achievement outcomes of eighth-grade students of low SES from multiple school districts would provide further information on the limitation of generalizability noted as a limitation of this study. In addition, this future research would add to the literature to determine the extent to which differences exist in summative assessment achievement outcomes for eighth-grade students of low SES from different school districts, based on years of participation in a one-to-one laptop program.

This study focused on the summative assessment achievement outcomes of eighth-grade students of low SES which was only one grade level. Future research addressing ELA and mathematics summative assessment achievement outcomes of students of low SES from different grade levels would be also be beneficial. This future research would add to the research literature to determine the extent to which differences exist in ELA and mathematics summative assessment achievement outcomes for students of low SES from various grade levels based on years of participation in a one-to-one laptop program. The study may also help school district decision-makers considering the return on investment of one-to-one laptop programs and potential impacts on student achievement. This information may be particularly interesting to school districts looking to address the problem space of the digital divide.

References

Adane, K. (2020). Threats introduced by bring your own devices (BYOD) Adoption in an Ethiopian higher educational institution: Solutions to security and privacy. *IUP Journal of Information Technology*, *17*(2), 7-29.

Adler-Greene, L. (2019). Every Student Succeeds Act: Are schools making sure every student succeeds? *Touro Law Review*, *35*(1), 11-23. https://www.govinfo.gov/content/pkg/PLAW-114publ95/pdf/PLAW-114publ95.pdf

Agasisti, T., Gil-Izquierdo, M., & Won Han, S. (2020). ICT Use at home for school-related tasks: what is the effect on a student's achievement? Empirical evidence from OECD PISA data. *Education Economics, 28*(6), 601-620. https://doi.org/10.1080/09645292.2020.1822787

Åkerblad, L., Seppänen-Järvelä, R., & Haapakoski, K. (2020). Integrative strategies in mixed methods research. *Journal of Mixed Methods Research, 15*(2). https://doi.org/10.1177/1558689820957125

AlDahdouh, A. A., Osorio, A. J., & Caires, S. (2015). Understanding knowledge network, learning and connectivism (ED572896). *International Journal of Instructional Technology and Distance Learning, 12*(10), 4-9. ERIC. https://files.eric.ed.gov/fulltext/ED572896.pdf

Allen, J., Mahamed, F., & Williams, K. (2020). Disparities in education: E-learning and COVID-19: Who matters? *Child & Youth Services, 41*(3), 208-210. https://doi.org/10.1080/0145935X.2020.1834125

Allen, M. (2017). *The sage encyclopedia of communication research methods*. Sage.

Anabo, I. F., Elexpuru-Albizuri, I., & Villardon-Gallego, L. (2019). Revisiting the Belmont Report's ethical principles in Internet-mediated research: Perspectives from disciplinary associations in the social sciences. *Ethics and Information Technology*, *2*(2), 137-138. https://doi.org/10.1007/s10676-018-9495-z

Anderson, M., & Perrin, A. (2018). *Nearly one-in-five teens can't always finish their homework because of the digital divide*. Pew Research Center. https://www.pewresearch.org/short-reads/2018/10/26/nearly-one-in-five-teens-cant-always-finish-their-homework-because-of-the-digital-divide/

Andrew, A., Cattan, S., Costa-Dias, M., Farquharson, C., Kraftman, L., Krutikova, S., Phimister, A., & Sevilla, A. (2020). *Learning during the lockdown: Real-time data on children's experiences during home learning*. Institute for Fiscal Studies. https://ifs.org.uk/publications/learning-during-lockdown-real-time-data-childrens-experiences-during-home-learning

Anil, Ö., Batdi, V., & Küçüközer, H. (2018). The effect of computer-supported education on student attitudes: A meta-analytical comparison for the period 2005-2015. *Educational Sciences*, *18*(1), 5-22. https://doi.org/10.12738/estp.2018d.0285

Apple. (2008). *Apple classrooms of tomorrow—today: Learning in the 21st century*. https://www.apple.com/ca/education/docs/Apple-ACOT2Whitepaper.pdf

Arghode, V. (2012). Qualitative and quantitative research: Paradigmatic differences. *Global Education Journal, 2012*(4), 155-163.

Bach, A., Wolfson T., & Crowell, J. (2018). Poverty, literacy, and social transformation: An interdisciplinary exploration of the digital divide. *Journal of Media Literacy Education, 10*(1), 22-41. https://doi.org/10.23860/jmle-2018-10-1-2

Backes, B., & Cowan, J. (2019). Is the pen mightier than the keyboard? The effect of online testing on measured student achievement. *Economics of Education Review*, *68*(1), 89-103. https://doi.org/10.1016/j.econedurev.2018.12.007

Baker, E. L., Gearhart, M., & Herman, J. L. (1993). *Apple classrooms of tomorrow: The UCLA evaluation studies* (ED378219). ERIC. https://files.eric.ed.gov/fulltext/ED378219.pdf

Bass, B. (2021). The effect of technology funding on school-level student proficiency. *Economics of Education Review, 84*, 102151. https://doi.org/10.1016/j.econedurev.2021.102151

Birman, B. F., & Ginsburg, A. L. (1983). A federal role for computers in the schools. *Theory Into Practice*, *22*(4), 281-282. https://doi.org/10.1080/00405.848309543075

Bixler, S. G. (2019). One-to-one iPad technology in the middle school mathematics and science classrooms (EJ1227035). *International Journal of Technology in Education and Science*, *3*(1), 1-18. ERIC. https://files.eric.ed.gov/fulltext/EJ1227035.pdf

Brewer, E., & Kubn, J. (2010). Causal-comparative design. In N. J. Salkind (Ed.), *Encyclopedia of research design* (pp. 125-131). Sage.

Buda, A. (2020). Stumbling blocks and barriers to the use of ICT in schools: A case study of a Hungarian town (EJ1257522). *Informatics in Education, 19*(2), 159-160. ERIC. https://files.eric.ed.gov/fulltext/EJ1257522.pdf

Campbell, A., Craig, T., & Collier-Reed, B. (2020). A framework for using learning theories to inform "growth mindset" activities. *International Journal of Mathematical Education in Science and Technology*, *51*(1), 26-43. https://doi.org/10.1080/0020739X.2018.1562118

Campbell, L. O., Howard, C., Lambie, G. W., & Gao, X. (2022). The efficacy of a computer-adaptive reading program on grade 5 students' reading achievement scores. *Education and Information Technologies*, *27*(6), 8147-8163. https://doi.org/10.1007/s10639-022-10953-5

Cancela, L. J. (2020). Bridging the digital divide. *International Trade Forum, 22*(1), 1-3. https://doi.org/10.18356/15645304-2020-3-7

Cates, W. M. (1993). Instructional technology: The design debate. *Clearing House*, *66*(3), 133-134. https://doi.org/10.1080/00098655.1993.9955950

Chen, S., & Bonanno, G. A. (2020). Psychological adjustment during the global outbreak of COVID-19: A resilience perspective. *Psychological Trauma*, *12*, S51-S54. https://doi.org/10.1037/tra0000685

Chiao, C., & Chiu, C.-H. (2018). The mediating effect of ICT usage on the relationship between students' socioeconomic status and achievement. *Asia-Pacific Education Researcher*, *27*(2), 109-121. https://doi.org/10.1007/s40299-018-0370-9

Cho, V. (2017). Vision, mission, and technology implementation: Going one-to-one in a Catholic school. *Journal of Catholic Education, 20*(2). http://dx.doi.org/10.15365/joce.2002082017

Chou, P.-N., Chang, C.-C., & Lin, C.-H. (2017). BYOD or not: A comparison of two assessment strategies for student learning. *Computers in Human Behavior, 74*(1), 63-71. https://doi.org/10.1016/j.chb.2017.04.024

Clemons, S. A. (2006). Constructivism pedagogy drives redevelopment of CAD course: A case study. *Technology Teacher,* 65(5), 19-21.

Coghlan, D., & Brydon-Miller, M. (2014). *The SAGE encyclopedia of action research*. Sage.

Common Core State Standards Initiative. (2020). *About the standards*. http://www.corestandards.org/about-the-standards/

Coşar, M., & Özdemir, S. (2020). The effects of computer programming on elementary school students' academic achievement and attitudes towards computer. *İlköğretim Online, 19*(3), 1509-1522. https://doi.org/10.17051/ilkonline.2020.732794

Domine, V. (2009). A social history of media, technology, and schooling (EJ1095263). *Journal of Media Literacy Education*, *1*(1), 42-52. ERIC. https://files.eric.ed.gov/fulltext/EJ1095263.pdf

Driscoll, M. P. (2000). *Psychology of learning for instruction*. Allyn & Bacon.

Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned (EJ508281). *Educational Leadership, 51*(7), 4-10. ERIC. https://files.eric.ed.gov/fulltext/EJ508281.pdf

Eakin, J. M., & Gladstone, B. (2020). "Value-adding" analysis: Doing more with qualitative data. *International Journal of Qualitative Methods, 19*. https://doi.org/10.1177/1609406920949333

Ellis, T. J., & Levy, Y. (2009). Towards a guide for novice researchers on research methodology: Review and proposed methods. *Issues in Informing Science & Information Technology*, *6*(2), 323-337. https://doi.org/10.28945/1062

Ercikan, K., & Roth, W-M. (2014). Limits of generalizing in education research: Why criteria for research generalization should include population heterogeneity and uses of knowledge claims. *Teachers College Record*, *116*(4). https://doi.org/10.1177/016146811411600405

Eubanks, V. E. (2007). Trapped in the digital divide: The distributive paradigm in community informatics. *Journal of Community Informatics*, *3*(2). https://doi.org/10.15353/joci.v3i2.2373

Fang, M. L., Canham, S. L., Battersby, L., Sixsmith, J., Wada, M., & Sixsmith, A. (2019). Exploring privilege in the digital divide: Implications for theory, policy, and practice. *Gerontologist, 59*(1), e1-e15. https://doi.org/10.1093/geront/gny037

Food Research and Action Center. (2020). *School meal eligibility and reimbursements*. https://frac.org/school-meal-eligibility-reimbursements

Fraillon, J., Ainley, J., Schulz, W., Duckworth, D., & Friedman, T. (2019). *IEA international computer and information literacy study 2018 assessment framework*. International Association for the Evaluation of Educational Achievement.

Frey, B. (2018). *The SAGE encyclopedia of educational research, measurement, and evaluation*. Sage.

Gajo, E., Oberwetter, J., Mathew, M., Dam, M., Sanborn, T., & Chehab, L. G. (2019). Correlation of sugar-sweetened beverage consumption and school free and reduced lunch eligibility as a measure of socioeconomic status. *Journal of Community Health, 44*(2), 307-312. https://doi.org/10.1007/s10900-018-0588-8

Gavin, H. (2008). Correlational designs: The poor relation? In H. Gavin (Ed.), *Understanding research methods and statistics in psychology* (pp. 168-186). Sage.

Gay, L., Mills, G., & Airasian, P. (2008). *Educational research: Competencies for analysis and application* (9th ed.). Merrill.

Graham, M. (2011). Time machines and virtual portals. *Progress in Development Studies*, *11*(3), 211-227. https://doi.org/10.1177/146499341001100303

Green, F. (2020). *Schoolwork in lockdown: New evidence on the epidemic of educational poverty*. Centre for Learning and Life Chances in Knowledge Economies and

Societies. https://www.llakes.ac.uk/wp-content/uploads/2021/01/67-Francis-Green-Research-Paper-combined-file.pdf

Hampton, K. N., Fernandez, L., Robertson, C. T., & Bauer, J. M. (2020). *Broadband and students performance gaps*. Quello Center. https://quello.msu.edu/wp-content/uploads/2020/03/Broadband_Gap_Quello_Report_MSU.pdf

Hanimoglu, E. (2018). The impact technology has had on high school education over the years (EJ1200405). *World Journal of Education*, *8*(6), 96-106. ERIC. https://files.eric.ed.gov/fulltext/EJ1200405.pdf

Hazlett, T. W., Schwall, B., & Wallsten, S. (2019). The educational impact of broadband subsidies for schools under E-rate. *Economics of Innovation and New Technology, 28*(5), 483-497. https://doi.org/10.1080/10438599.2018.1527554

Hearne, J. D., & Lasley, J. (1985). The relationship between achievement factors and gender-specific computer aptitude among junior high school students. *Education*, *106*(1), 81-87.

Heise, M. (2017). From No Child Left Behind to Every Student Succeeds: Back to a future for education federalism. *Columbia Law Review,* 117(7), 1859-1896.

Hoffman, D. L., & Novak, T. P. (1998). *Bridging the digital divide: The impact of race on computer access and internet use* (ED421563). ERIC. https://files.eric.ed.gov/fulltext/ED421563.pdf

Hohlfeld, T. N., & Ritzhaupt, A. D. (2018). An examination of the digital divide and its dividing factors in formal educational settings. In A. H. Normore & A. I. Lahera, A. I. (Eds.), *Crossing the bridge of the digital divide: A walk with global leaders* (pp. 19-36). Information Age.

Hohlfeld, T. N., Ritzhaupt, A. D., Barron, A. E., & Kemker, K. (2008). Examining the digital divide in K-12 public schools: Four-year trends for supporting ICT literacy in Florida. *Computers & Education*, *51*(4), 1648-1663. https://doi.org/ 10.1016/j.compedu.2008.04.002

Hohlfeld, T. N., Ritzhaupt, A. D., Dawson, K., & Wilson, M. L. (2017). An examination of seven years of technology integration in Florida schools: Through the lens of the levels of digital divide in schools. *Computers & Education*, *113*(2), 135-161. https://doi.org/10.1016/j.compedu.2017.05.017

Hopkins, N., Tate, M., Sylvester, A., & Johnstone, D. (2017). Motivations for 21st century school children to bring their own device to school. *Information Systems Frontiers*, *19*(5), 1191-1203. https://doi.org/10.1007/s10796-016-9644-z

Hosszu, A., & Rughiniș, C. (2020). Digital divides in education. An analysis of the Romanian public discourse on distance and online education during the COVID-19 pandemic. *Sociologie Românească, 18*(2). https://doi.org/10.33788/sr.18.2.1

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.org/10.3102/0162373718799969

Husband, T., & Hunt, C. (2015). A review of the empirical literature on No Child Left Behind from 2001 to 2010 (EJ1145269). *Planning & Changing*, *46*(1/2), 212-254. ERIC. https://files.eric.ed.gov/ fulltext/EJ1146269.pdf

Jacobsen, L. A. (2020). *Digital and economic divide put U.S. children at greater educational risk during the COVID-19 pandemic*. Population Reference Bureau. https://www.prb.org/resources/economic-and-digital-divide/

Karlsson, L. (2020). Computers in education: The association between computer use and test scores in primary school*, Education Inquiry, 13*(1), 56-85. https://doi.org/10.

1080/20004508.2020.1831288

Kay, R., & Schellenberg, D. (2019, March). *Comparing BYOD and one-to-one laptop programs in secondary school classrooms: A review of the literature* [Conference session]. Society for Information Technology & Teacher Education International Conference, Las Vega, NV, United States.

Kert, S. B., Kalelioglu, F., & Gulbahar, Y. (2019). A holistic approach for computer science education in secondary schools (EJ1212879). *Informatics in Education, 18*(1), 131-150. ERIC. https://files.eric.ed.gov/fulltext/EJ1212879.pdf

Kim, T. K. (2015). T-test as a parametric statistic. *Korean Journal of Anesthesiology*, 68(6), 540-546. https://doi.org/10.4097/kjae.2015.68.6.540

Kirk, R. E. (2013). Research strategies and the control of nuisance variables. In R. E. Kirk (Ed.), *Experimental design: Procedures for the behavioral sciences* (pp. 1-29). Sage.

Kozakowski, W. (2019). Moving the classroom to the computer lab: Can online learning with in-person support improve outcomes in community colleges? *Economics of Education Review*, *70*(3), 159-172. https://doi.org/10.1016/j.econedurev.2019.03.004

Kozleski, E. B. (2017). The uses of qualitative research: Powerful methods to inform evidence-based practice in education. *Research and Practice for Persons with Severe Disabilities, 42*(1), 19-32. https://doi.org/10.1177/1540796916683710

Kuhfeld, M., Domina, T., & Hanselman, P. (2019). Validating the SEDA measures of district educational opportunities via a common assessment. *AERA Open*, *5*(2). https://doi.org/10.1177/2332858419858324

Kupriyanova, M., Dronov, V., & Gordova, T. (2019). Digital divide of rural territories in

Russia. *Agris On-Line Papers in Economics & Informatics*, *11*(3), 85-90.

Laerd Statistics. (2020). *Descriptive and inferential statistics*. https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php

Laerd Statistics. (2023a). *External validity*. https://dissertation.laerd.com/external-validity

Laerd Statistics. (2023b). *Independent-samples t test using SPSS statistics*. https://statistics.laerd.com/spss-tutorials/independent-samples-t-test-using-spss-statistics.php

Laerd Statistics. (2023c). *Independent-samples t test using SPSS statistics: Dealing with outliers*. https://statistics.laerd.com/premium/spss/istt/independent-t-test-in-spss-10.php

Laerd Statistics. (2023d). *Independent t test for two samples*. https://statistics.laerd.com/statistical-guides/independent-t-test-statistical-guide.php

Laerd Statistics. (2023e). *Internal validity*. https://dissertation.laerd.com/internal-validity.php

Laerd Statistics. (2023f). *One-sample t test using SPSS statistics*. https://statistics.laerd.com/spss-tutorials/one-sample-t-test-using-spss-statistics.php

Laerd Statistics. (2023g). *Purposive sampling*. http://dissertation.laerd.com/purposive-sampling.php#total

Laerd Statistics. (2023h). *Sampling strategy.* http://dissertation.laerd.com/sampling-strategy.php

Laerd Statistics. (2023i). *Total population sampling*. http://dissertation.laerd.com/total-population-sampling.php

Lamb, A. J., & Weiner, J. M. (2018). Extending the research on 1:1 technology integration in middle schools: A call for using institutional theory in educational technology research (EJ1175684). *Middle Grades Review, 4*(1). ERIC. https://files.eric.ed.gov/fulltext/EJ1175684.pdf

Lanford, M., Corwin, Z. B., Maruco, T., & Ochsner, A. (2019). Institutional barriers to innovation: Lessons from a digital intervention for underrepresented students applying to college. *Journal of Research on Technology in Education*, *51*(3), 203-216. https://doi.org/10.1080/15391523.2019.1576558

Liabo, K., Langer, L., Simon, A., Daniel-Gittens, K., Elwick, A., & Tripney, J. (2016). Protocol for a systematic review: Provision of information and communications technology (ICT) for improving academic achievement and school engagement in students aged 4-18. *Campbell Systematic Reviews*, *12*(1), 1-49. https://doi.org/10.1002/CL2.163

Liu, F., Ritzhaupt, A., Dawson, K., & Barron, A. (2017). Explaining technology integration in K-12 classrooms: A multilevel path analysis model. *Educational Technology Research & Development*, *65*(4), 795-813. https://doi.org/10.1145/155049.155073

Machin, S., McNally, S., & Silva, O. (2007). New technology in schools: Is there a payoff? *Economic Journal*, *117*(522), 1145-1167. https//doi.org/10.1111/j.1468-0297.2007.02070.x

Mann, B. (2019). Whiteness and economic advantage in digital schooling: Diversity patterns and equity considerations for K-12 online charter schools. *Education Policy Analysis Archives, 27*(105). https://doi.org/10.14507/epaa.27.4532

McGregor, S. (2018). Introduction and research questions. In S. McGregor (Ed.), *Understanding and evaluating research* (pp. 139-175). Sage.

McLean, K. J. (2016). The implementation of bring your own device (BYOD) in primary [elementary] schools. *Frontiers in Psychology.* https://doi.org/10.3389/fpsyg. 2016.01739

McMillan, J. H. (2016). *Fundamentals of educational research* (7th ed.). Pearson.

Meyer, K. E. M. (2017). *An analysis of the impact of one-to-one laptops on student academic performance* (Publication No. 10624735) [Doctoral dissertation, Grand Canyon University]. ProQuest Dissertations and Theses Global.

Mills, G. E., & Gay, L. R. (2019). *Educational research: Competencies for analysis and applications*. Pearson.

Mora, T., Escardíbul, J-O., & Di Pietro, G. (2018). Computers and students' achievement: An analysis of the one laptop per child program in Catalonia. *International Journal of Educational Research*, *92*(2018), 145-157. https://doi. org/10.1016/j.ijer.2018.09.013

Muijs, D. (2004). Introduction to quantitative research. In D. Muijs (Ed.), *Doing quantitative research in education with SPSS* (pp. 1-12). Sage.

Muñiz, R. (2021). Education law and policy in the time of COVID-19: Using a legal framework to expose educational inequity. *AERA Open*, *7*. https://doi.org/10. 1177/23328584211054107

Natt och Dag, K. (2017). A scholar-practitioner perspective on a leadership development program in health care: Integrating Connectivism Theory. *Advances in Developing Human Resources, 19*(3), 295-313. https://doi.org/10.1177/1523. 422317712671

Nayar, K. A., & Barker, M. (2014). Computer labs as techno-pedagogical tools for learning biology: Exploring ICT practices in India. *Asia-Pacific Forum on Science Learning & Teaching, 15*(1), 1-19.

Neuman, S. B., Kaefer, T., & Pinkham, A. M. (2018). A double dose of disadvantage: Language experiences for low-income children in home and school. *Journal of Educational Psychology, 110*(1), 102-118. https://doi.org/10.1037/edu0000201

Nishishiba, M., Jones, M., & Kraner, M. (2014). Comparing means between two groups. In M. Nishishiba, M. Jones, & M. Kraner (Eds.), *Research methods and statistics for public and nonprofit administrators* (pp. 171-192). Sage.

Nkemakolam, O. E., Chinelo, O. F., & Jane, M. C. (2018). Effect of computer simulations on secondary school students' academic achievement in chemistry in Anambra State. *Asian Journal of Education and Training*, *4*(4), 284-289. https://doi.org/10.20448/journal.522.2018.44.284.289

Nussbaum, M., Alcoholado, C., & Büchi, T. (2015). A comparative analysis of interactive arithmetic learning in the classroom and computer lab. *Computers in Human Behavior, 43*(2), 183-188. https://doi.org/10.1016/j.chb.2014.10.031

Office of Elementary and Secondary Education. (1998). *Goals 2000: Reforming education to improve student achievement: Report to Congress* (ED420918). ERIC. https:// files.eric.ed.gov/fulltext/EJ1175684.pdf

Office of Superintendent of Public Instruction. (2022). *Washington state report card.* https://washingtonstatereportcard.ospi.k12.wa.us/Report.Card/View.School.Or.District/100142

Organization for Economic Cooperation and Development. (2012). *Equity and quality in education: Supporting disadvantaged students and schools*. https://www.oecd.org/education/school/50293148.pdf

Pan, W., & Sass, T. (2020). *Potential remediation strategies in the wake of COVID-19 school closures: A review of the literature*. Georgia Policy Labs. https://core.ac.

uk/download/pdf/344771795.pdf

Pan, X., & Shao, H. (2020). Teacher online feedback and learning motivation: Learning engagement as a mediator. *Social Behavior & Personality: An International Journal, 48*(6), 1-10. https://doi.org/10.2224/sbp.9118www.sbp-journal.com

Park, J., & Park, M. (2016). Qualitative versus quantitative research methods: Discovery or justification? *Journal of Marketing Thought*, *3*(1), 1-7. https://doi.org/10. 15577/jmt.2016.03.01.1

Pérez-Castro, M. Á., Mohamed-Maslouhi, M., & Montero-Alonso, M. Á. (2021). The digital divide and its impact on the development of Mediterranean countries. *Technology in Society, 64*. https://doi.org/10.1016/j.techsoc.2020.101452

Pick, J. B., & Nishida, T. (2015). Digital divides in the world and its regions: A spatial and multivariate analysis of technological utilization. *Technological Forecasting & Social Change*, *91*(1). https://doi.org/10.1016/j.techfore.2013.12.026

Poirot, J. L., Taylor, H. G., & Norris, C. A. (1988). Retraining teachers to teach high school computer science. *Communications of the ACM*, *31*, 912-917. https://doi. org/10.1145/48511.48521

Powers, J. R., Musgrove, A., T., & Nichols, B., H. (2020). Teachers bridging the digital divide in rural schools with 1:1 computing. *Rural Educator*, *41*(1). https://doi.org/ 10.35608/ruraled.v41i1.576

Putri, W. C., Yuwinanto, H. P., & Gunarti, E. (2020). Digital divide among adolescents. *Talent Development & Excellence, 12*(2), 434-442.

Qadir, M. J., & Hameed, A. (2018). Usefulness of Punjab IT labs project in schools of Punjab, Pakistan. *Journal of Educational Research*, *21*(2), 137-146.

Rebmann, K., Means, D., Riedesel, L., & McDowell, R. (2019). Addressing the homework gap with TV white space networking technology. *Teacher Librarian, 46*(3), 13-16.

Reddick, C. G., Enriquez, R., Harris, R. J., & Sharma, B. (2020). Determinants of broadband access and affordability: An analysis of a community survey on the digital divide. *Cities, 106*, 102904. https://doi.org/10.1016/j.cities.2020.102904

Reese, S. (1998). Music learning in your school computer lab. *Music Educators Journal, 85*(3), 31-33. https://doi.org/10.2307/3399143

Reid, W., & Taylor, R. (1989). The recovery of sunk costs and sunk power: Raising the Titanic of school-based computers and data. *Education*, *109*(3), 358-360.

Reimer, D., Smith, E., Andersen, I. G., & Sortkær, B. (2021). What happens when schools shut down? Investigating inequality in students' reading behavior during COVID-19 in Denmark. *Research in Social Stratification and Mobility*, *71*, 100568. https://doi.org/10.1016/j.rssm.2020.100568

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

Reza, F. (2020). COVID-19 and disparities in education: Collective responsibility can address inequities. *Knowledge Cultures, 8*(3), 68-75. https://doi.org/10.22381/KC83202010

Ritter, F. E., Kim, J. W., Morgan, J. H., & Carlson, R. A. (2013). Concluding a study. In F. E. Ritter, J. W. Kim, J. H. Morgan, & R. A. Carlson (Eds.), *Running behavioral studies with human participants: A practical guide* (pp. 121-136). Sage.

Rizk, J., & Davies, S. (2021). Can digital technology bridge the classroom engagement gap? Findings from a qualitative study of K-8 classrooms in 10 Ontario school boards. *Social Sciences, 10*(12). https://doi.org/10.3390/socsci10010012

Robinson, L., Wiborg, Ø., & Schulz, J. (2018). Interlocking inequalities: Digital stratification meets academic stratification. *American Behavioral Scientist, 62*(9), 1251-1272. https://doi.org/10.1177/0002764218773826

Rogers, S. (2016). Bridging the 21st-century digital divide. *Tech Trends*, *60*(3), 197-199. https://doi.org/10.1007/s11528-016-0057-0

Salkind, N. J. (2010a). *Encyclopedia of measurement and statistics*. Sage.

Salkind, N. J. (2010b). *Encyclopedia of research design*. Sage.

Sarma, S. K. (2015). Data collection in organizational research: Experiences from the field. *International Journal of Rural Management*, *11*(1), 75-81. https://doi.org/10.1177/0973005215569384

Schenker, J. D., & Rumrill, J. P. D. (2004). Causal-comparative research designs. *Journal of Vocational Rehabilitation*, *21*(3), 117-121.

Scherer, R., & Siddiq, F. (2019). The relation between students' socioeconomic status and ICT literacy: Findings from a meta-analysis. *Computers & Education, 138*, 13-32. https://doi.org/10.1016/j.compedu.2019.04.011

Semenikhina, E., Drushlyak, M., Bondarenko, Y., Kondratiuk, S., & Dehtiarova, N. (2019). Cloud-based service GeoGebra and its use in the educational process: The BYOD-approach. *TEM Journal, 8*(1), 65-72. https://doi.org/10.18421/TEM81-08

Setthasuravich, P., & Kato, H. (2020). The mediating role of the digital divide in outcomes of short-term transportation policy in Thailand. *Transport Policy*, *97*(2), 161-171. https://doi.org/10.1016/j.tranpol.2020.07.008

Shah, V., & Shaker, E. (2020). *Leaving normal: Re-imagining schools post-COVID and beyond*. https://policyalternatives.ca/sites/default/files/uploads/publications/

Leaving_normal.pdf

Shami-Iyabo, M. (2020). Ethical concerns of school closures for low-income school-aged children. *Voices in Bioethics*, *6*. https://doi.org/10.7916/vib.v6i.7057

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, *2*(1), 3-10.

Siemens, G. (2018). Connectivism. In R. West (Ed.), *Foundations of learning and instructional design technology*. https://edtechbooks.org/lidtfoundations

Singh, M., Dunn, H. H., & Burke, A. M. (2020). Revealing the variation in performance of Hawai'i's Asian Pacific Islander subgroups on the English language arts smarter balanced assessment: Implications for policy and practice. *International Journal of Educational Research*, *103*, 101614. https://doi.org/10.1016/j.ijer.2020.101614

Smarter Balanced Assessment Consortium. (2014a). *Content specifications for the summative assessment of the common core state standards for English language arts and literacy in history/social studies, science, and technical subjects*. https://portal.smarterbalanced.org/library/en/english-language-artsliteracy-content-specifications.pdf

Smarter Balanced Assessment Consortium. (2014b). *Content specifications for the summative assessment of the common core state standards for mathematics*. https://portal.smarterbalanced.org/library/en/mathematics-content-specifications.pdf

Smarter Balanced Assessment Consortium. (2015). *2014-15 summative technical report*. https://portal.smarterbalanced.org/library/en/2014-15-technical-report.pdf

Smarter Balanced Assessment Consortium. (2016). *2015-16 summative technical report*.

https://portal.smarterbalanced.org/library/en/2015-16-summative-technical-report.pdf

Smarter Balanced Assessment Consortium. (2017). *2016-17 summative technical report*. https://portal.smarterbalanced.org/library/en/2016-17-summative-assessment-technical-report.pdf

Smarter Balanced Assessment Consortium. (2018). *2017-18 summative technical report*. https://portal.smarterbalanced.org/library/en/2017-18-summative-assessment-technical-report.pdf

Smarter Balanced Assessment Consortium. (2019). *2018-19 summative technical report*. https://technicalreports.smarterbalanced.org/2018-19_summative-report/_book/index.html

Smarter Balanced Assessment Consortium. (2020). *Reporting scores: Scaled scores*. http://www.smarterbalanced.org/assessments/scores/

Smarter Balanced Assessment Consortium. (2021). *Summative assessment: The end-of-year test*. http://www.smarterbalanced.org/assessments/

Smarter Balanced Assessment Consortium. (2022). *What is smarter balanced?* http://www.smarterbalanced.org/about/

Smith, K., & Wheeler, K. L. (2019). Using the smarter balanced grade 11 summative assessment in college writing placement. *Assessing Writing*, *41*, 76-79. https://doi.org/10.1016/j.asw.2019.06.002

Soomro, K. A., Kale, U., Curtis, R., Akcaoglu, M., & Bernstein, M. (2020). Digital divide among higher education faculty. *International Journal of Educational Technology in Higher Education, 17*(1), 1-16. https://doi.org/10.1186/s41239-020-00191-5

Soria, K. M., & Horgos, B. (2020). *Social class differences in students' experiences during the COVID-19 pandemic*. SERU Consortium, University of California at Berkeley and University of Minnesota. https://cshe.berkeley.edu/seru-covid-survey-reports

Talaee, E., & Noroozi, O. (2019). Re-conceptualization of "digital divide" among primary school children in an era of saturated access to technology (EJ1232742). *International Electronic Journal of Elementary Education, 12*(1), 27-35. ERIC. https://files.eric.ed.gov/fulltext/EJ1232742.pdf

Tan, J. J. X., Kraus, M. W., Carpenter, N. C., & Adler, N. E. (2020). The association between objective and subjective socioeconomic status and subjective well-being: A meta-analytic review. *Psychological Bulletin*, *146*(11), 970-1020. https://doi.org/10.1037/bul0000258

Thomlinson, B. (2001). Descriptive studies. In B. A. Thyer (Ed.), *The handbook of social work research methods* (pp. 131-141). Sage.

Tucker, M. (1983). Computers in schools: A plan in time saves nine. *Theory Into Practice*, *22*(4), 313-314. https://doi.org/10.1080/00405848309543080

U.S. Department of Health and Human Services. (1979). *The Belmont report: Ethical principles and guidelines for the protection of human subjects of research*. https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html

U.S. Department of Labor. (1991). *What work requires of schools: A SCANS report for America 2000* (ED332054). ERIC. https://files.eric.ed.gov/fulltext/ED332054.pdf

van Deursen, A. J., & van Dijk, J. A. (2019). The first-level digital divide shifts from inequalities in physical access to inequalities in material access. *New Media &*

Society, *21*(2), 354-375. https://doi.org/10.1177/1461444818797082

van Dijk, J. (2005). *The deepening divide: Inequality in the information society.* Sage.

van Dijk, J. (2006). Digital divide research, achievements, and shortcomings. *Poetics, 34*(4), 221-235. https://doi.org/10.1016/j.poetic.2006.05.004

van Dijk, J., & Hacker, K. (2003). The digital divide as a complex and dynamic phenomenon. *Information Society, 19*, 315-326.

Van Orden, A. (2020). *Remediation in Maryland higher education. Part 1: Remediation, and why does it matter* (ED604255). ERIC. https://files.eric.ed.gov/fulltext/ ED604255.pdf

Vu, P., Fredrickson, S., & Gaskill, M. (2019). One-to-one initiative implementation from insiders' perspectives. *Tech Trends, 63*(1), 62-67. https://doi.org/10.1007/s11528-018-0359-5

Wagner, W., & Gillespie, B. (2019). 8 hypothesis testing and statistical significance. In W. Wagner & B. Gillespie (Eds.), *Using and interpreting statistics in the social, behavioral, and health sciences* (pp. 113-146). Sage.

Weber, M., & Becker, B. (2019). Browsing the web for school: Social inequality in adolescents' school-related use of the Internet. *Sage Open*, *9*(2), 1-15. https:// doi.org/10.1177/2158244019859955

Whetzel, D. (1992). *The Secretary of Labor's commission on achieving necessary skills* (ED339749). ERIC. https://files.eric.ed.gov/fulltext/ED339749.pdf

Whitehead, R. L. (2019). *Academic impact of an after-school program on middle school students from single-parent families* (Publication No. 13426297) [Doctoral dissertation, Grand Canyon University]. ProQuest Dissertations and Theses Global.

Willig, C. (2019). What can qualitative psychology contribute to psychological knowledge? *Psychological Methods, 24*(6), 796–804. https://doi.org/10.1037/met0000218

Yanguas, M. L. (2020). Technology and educational choices: Evidence from a one-laptop-per-child program. *Economics of Education Review*, *76*, 101984. https://doi.org/ 10.1016/j.econedurev.2020.101984

Yu, L. (2006). Understanding information inequality: Making sense of the literature of the information and digital divides. *Journal of Librarianship and Information Science*, *38*(4), 229-252.

Zawacki-Richter, O., & Latchem, C. (2018). Exploring four decades of research in Computers & Education. *Computers & Education, 122*, 136-152. https://doi.org/10.1016/j.compedu.2018.04.001

Zia, A., Naz, I., & Qureshi, U. (2017). Role of information and communication technologies in knowledge gap: A comparative study of public and private schools in Lahore, Pakistan. *Journal of Research & Reflections in Education*, *11*(2), 124-140.