EXPLORING THE ROI OF 1:1 COMPUTING PROGRAMS AT THE HIGH SCHOOL LEVEL

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This dissertation explored the cost and value of 1:1 computing programs in high schools in Texas. The study examines whether the total cost of ownership of these programs can be justified by the student testing gains and graduation rates. It investigates whether student learning outcomes show a definable correlation between positive gains and the implementation of 1:1 computing programs. The study also explores whether there is a measurable return on investment of 1:1 programs based on testing gains and graduation rates. The research used the State of Texas Assessment of Academic Readiness exam scores to validate assumptions and test the hypothesis. The study found no clear link between the addition of 1:1 computing programs and the realms of student success. While there is marginal improvement in student outcomes, there is only circumstantial evidence that laptops and devices are the catalysts for the change. The dissertation also found that the total cost of ownership (TCO) is a significant portion of the district's spending, costing millions of dollars, and that the financial disclosure and budget information data was either missing, incomplete, or over-generalized, causing an issue for assessing program effectiveness or ROI. Despite this lack of transparency, there is a slight positive ROI trend based on the data reviewed during the observation period.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The idea of a personal computer was a fantasy half a century ago, and the concept of each student using a device that functioned like a pen and notebook was a work of pure science fiction. However, Seymour Papert, the father of educational computing, discussed children using computers to learn and enhance creativity, innovation, and concrete rising computational thinking as early as 1960 (Stager, 2016).

Technological changes in school learning environments have been substantial over the past 15 years. For example, according to the National Center for Education Statistics (NCES), in 1994, only 3% of public school classrooms, computer labs, and library media centers had internet access (1997), and fourteen years later, 97% of public school classrooms had an internet connection (NCES 2010a).

Student-to-computer ratios also decreased significantly over this time. For example, in 1996, the national student-to-computer ratio in public schools was 11:1, but by 2009, the student-to-computer ratio had dropped to just seven to one (NCES, 2010b; McLeod & Richardson, 2013).

Very few educational initiatives have had as significant an impact and cost implication as integrating computer technologies into United State's classrooms. US schools dramatically improved their technological capacity, predominantly driven by public and private investment, professional development, and technical support (Dickard, 2003). The initiative was rolled out due to the belief that increased use of computers would improve teaching and learning, deliver greater efficiency, and develop students' essential skills. State and Federal governments have prioritized the introduction of computers in classrooms, as evidenced by the billions of dollars distributed to schools to provide access to technology and the internet for all students throughout the United States (Culp et al., 2005). Educational leaders have made multi-billion-dollar investments in educational technologies (Russell et al., 2004; Bebell & Kay, 2010; Facer & Selwyn, 2021; Hawthorne, 2021).

Over the last 25 years, US schools and districts, including rural, urban, and suburban, have received unprecedented funding to establish digital infrastructures. This funding provided connectivity throughout all school buildings and on devices such as iPads, Chromebooks, and interactive whiteboards. The funding streams are varied depending on the state; however, all US schools can access funding from the federal schools and libraries program, also known as the E-rate Program (E-Rate, 2023). In 2016, $338 million was allocated to expand access to broadband services and Wi-Fi capabilities nationally. In addition, the E-rate Program is allocating an additional $5 billion towards improving Wi-Fi over the next five years. According to an FCC press release, this effort can potentially increase Wi-Fi access by 75% in rural and urban schools over the next five years (Simpson, 2020).

An example of a state-level school funding source is the New York State Smart Schools Act. In 2014, Governor Cuomo called for the state to invest $2 billion and its schools during his State of the State Address. He stated that it would fund educational technology purchases and infrastructure advancements and provide students access to the latest technology and connectivity needed to succeed and compete in the global economy (Cuomo, 2016). As a result, New Yorkers voted for the Smart Schools Bond Act in November 2014 (Cuomo, 2016).

As a field, education is changing, and decisions on how to best utilize the influx of technologies available are evolving. A clear trend is emerging in schools throughout the United

States; students are provided with computing devices, such as tablets and laptops, to use at school and home for learning (Christensen & Knezek, 2017). Past research indicated that virtually all middle and high school students have access to a mobile device and use it for schoolwork, with nearly a third using mobile devices issued by their schools (Christensen & Knezek, 2017). In addition, many districts provide devices to all students in a classroom or building to use in school and at home. This initiative is most often referred to as a *1:1 computing program*. These implementations provide each student with their own computing device. Such programs provide educational access to technology that is not shared; instead, all students and staff have ubiquitous access to individual devices (Downes & Bishop, 2015).

Advocates of 1:1 computing programs suggest that this designated use of technology in schools has the potential to radically change teaching and learning practices in the same way computing devices have impacted other areas of society, such as communication, entertainment, and e-commerce (Armstrong, 2014; Weston & Bain, 2010). Educational theorist and author Seymour Papert argued over 30 years ago that providing students with powerful technologies may change how students think and retain information (Benell & Kay, 2009).

Technology for the sake of technology is rarely the goal of a school or state’s decision to invest the requisite funds to provide support in the format of computers for their students and staff; however, the context and expectations ranged widely for 1:1 computing implementation models. This outcome occurs because the models, by definition, only describe the ratio of technology access and not how it will be used to support teaching or learning (Bebell & O’Dwyer, 2010). In the environments where 1:1 computing programs are implemented, increased use of digital technologies was indicated by some studies; however, teaching and learning frequently remained fundamentally the same as in classrooms without these tools

(Howard et al., 2015). Thus, providing teachers and students with abundant access to laptop technology is only the first step toward using technology as an effective tool that may significantly impact student learning outcomes (Levin & Wadmany, 2006).

Overall, little research can be found to support the return on these substantial investments. Research has been inconsistent in determining the actual effect of 1:1 computing programs on student achievement and the impact on long-term educational gains. In many areas, the expenditure associated with a 1:1 computing program's five-year implementation costs likely outweighs other professional development and student resources. An economic argument against 1:1 computing programs may be that they will cost more, and not less, over a five-year plan because of maintenance, support, insurance, software, infrastructure, and repair (Toper & Lancaster, 2013). Computing programs consist of much more than the price of buying computers and connecting them to networks. Schools should consider the total cost of ownership (TCO), including training teachers and administrators, technical support, software, replacement costs of aging equipment, and other items. In the United States, the direct and indirect costs of 1:1 programs per client computer can be up to $1000 based on a price sheet from Gartner. Hardware composes only about one-third of the total cost in a developing nation, whereas training, service, and support account for more than half. However, comparing TCO to a baseline of zero is a mistake. No school will remove all computers and Wi-Fi connections, and teachers will continue to use online resources. Internationally, desktop computers have become far more prevalent in schools in many nations during the past decade (US. Department of Education, 2017), with 1:1 computing programs adding to school expenses. It is expected that computing programs will reduce certain costs, such as textbooks and assessment costs. Nevertheless, the question is whether those costs are acceptable based on students' gains when given access to 1:1 computing programs.

1.2 Statement of the Problem

Nearly a decade ago, when school systems began providing millions of dollars to purchase laptop computers for every student, these programs (often called one-to-one or ubiquitous computing initiatives) were heralded as having the potential to close persistent technology gaps. However, some schools implementing the 1:1 computer programs amid great fanfare are ending these implementations due to budget cuts, growing maintenance and replacement costs, and concerns about how students use the computers (Hu, 2007). Nevertheless, many district leaders believe that 1:1 computing programs are worth the expense and headaches. A recent survey of 364 leaders of large districts with 1:1 computing programs found that 33 percent believed the laptops significantly affected student achievement, and another 45 percent believed they had a *moderate* effect (Greaves & Hayes, 2008). Of course, such self-reporting is prone to subjectivity.

The reasons given by policymakers for investing in these programs vary. For example, economic arguments are based on improving students' technology skills, creating a better-educated workforce, and attracting new jobs (Penuel, 2006; Christensen & Knezek, 2017; Owens, 2022). In addition, there are equity concerns about supporting students from low-income families whose access to technology and information is otherwise restricted (Andrade Johnson, 2020). There are also Education reform issues, with policymakers trying to make schools more effective and provide students with an education that prepares them for the 21st Century (Owens, 2022). However, it does not seem that these arguments are based on more than personal accounts and personal beliefs in the power of technology.

Overall, large-scale evaluations of 1:1 computing programs found mixed or no results regarding positively impacting educational goals. For example, after five years of implementation with the state of Maine's computing program, which was one of the most extensive 1:1 computing programs in the United States, little effect on student achievement was found in the evaluation—with one exception, writing, where the scores edged up 3.44 points (in a range of 80 points) in five years (Silvernail & Gritter, 2007). The evaluators speculated that other subjects had not shown measurable improvement because the state assessment does not measure the 21st Century technology skills that laptop initiatives promote.

An evaluation of Michigan's 1:1 computing programs found similarly mixed results. It examined eight matched pairs of schools and found higher achievement in four laptop schools, lower achievement in three, and no difference in the final pair (Lowther et al., 2007). The study of Texas middle school students referenced earlier found slightly higher student growth in mathematics but no improvement in reading for students participating in 1:1 computing programs (Shapley et al., 2009). Furthermore, unlike in Maine, writing scores were lower (although not significantly so) for students in the laptop group; the researchers reasoned that students may have grown so accustomed to writing with computers that they had trouble adjusting to the pencil-and-paper format of the state test. Many educators assume that enabling ubiquitous access to technology will lead to positive results. However, Bebell and O'Dwyer's (2010) research found more positive outcomes when schools focused on more training and immersion rather than just implementing 1:1 computing programs.

One effective implementation was the Texas Technology Immersion Pilot. The state invested nearly $14.5 million with a four-year immersion goal, and the study involved students in 22 schools receiving computers. However, the same inconsistent performance findings were demonstrated, like the implementation within Maine. At the end of the fourth year, student access to and usage of computers was below the intended goals. Most concerning, despite the significant financial investment, there was still no evidence that student performance or school satisfaction had increased (Weston & Bain, 2010). So, it all leads back to the question of ROI; can states, districts, and schools justify the ballooning costs with little evidence of strong academic outcomes?

1.3 Statement of Purpose

This study has examined the relationship between the financial cost of 1:1 computing programs and the benefit of these programs to students, exploring the total cost of ownership for 1:1 computing programs within a school district and assessing the program's return on investment.

This study aimed to determine if there was a clear, measurable ROI for 1:1 computing programs. A large body of research looked at the academic effect 1:1 technology has on educational outcomes, though there is not a universal outcome that is agreed upon in this body. Moreover, along with the lack of an agreed outcome, there is no shown correlation that the expenditure on a 1:1 computing program will advance student outcomes significantly more than other academic investments. This study sought justification for some of the most extensive academic spending programs in the last 10-20 years.

1.4 Research Questions

This study drew upon the following research questions:

1. Can the total cost of ownership (TCO) of a 1:1 computing program be justified by the student testing gains and graduation rates?
2. Can student learning outcomes show a definable correlation between positive gains and the implementation of 1:1 computing programs?

3. Is there a measurable return on investment of 1:1 computing programs in districts based on testing gains and graduation rates?

1.5 Rationale and Significance

Nowadays, computing devices and other technology are a minimum requirement for education at the least, and at best, a tool to help students of all levels succeed in an educational setting. 1:1 programs are starting in the United States and worldwide. Some see this as the latest in a long line of buzzword, short-sighted solutions, while others believe that technology will revolutionize education for all. Education will continue implementing technology to improve student access or reduce onerous teaching tasks like grading multiple-choice tests. However, the question remains whether that technology helps the students on its own or is it one part of a dynamic picture.

As more technology evolves and enters the education sector, costs keep changing. Even if the cost of a mobile device is declining yearly, that does not mean the long-term cost of the school or district shrinks. Educational spending is a political issue that gets churned and rechurned every cycle, and year-over-year, significant spending is focused on technology. While most people see technology as a good thing based on personal experience and knowledge, no cost analysis shows the ROI of these programs.

As we pass through the COVID-19 pandemic and this massive change to the American culture and views of education, spending on technology is expected to rise again. The current significant change in education is why research like this is needed. Districts must understand the financial cost of 1:1 computing programs and what academic performance returns they can expect from their significant investment.

Six of Texas's ten largest school districts have complete 1:1 initiatives (TEA, 2022): Houston ISD, Dallas ISD, Cypress-Fairbanks ISD, Fort Worth ISD, Austin ISD, and Aldine ISD.

Two of the ten districts have bring-your-own-device (BYOD) programs: Fort Bend ISD and Northeast ISD. Two districts do not have official programs but utilize educational technology that would require some form of mobile technology for student learning: Katy ISD and Conroe ISD use Canvas, a learning management system.

1.6 Key Terms

- *Continued rate:* A subcategory of High School Completion rate. It refers to the longitudinal representation of the percentage of students form a class of beginning ninth graders who complete their high school education by continuing in high school in the fall after graduation was expected (TEA, 2020).
- *One-to-one, or 1:1*: Using Penuel's (2006) definition, 1:1 in this study assumes a student has a laptop, netbook, tablet, or another mobile computing device they can take home daily. Students can use this device to access the internet at school or other places with the focus of helping students complete academic tasks.
- *Return on investment:* A metric to understand the profitability of an investment. Comparison of how much was paid for the investment to its current value. This calculation helps managers understand the profit or loss the investment has earned (Forbes, 2021).
- *STAAR:* State of Texas Assessments of Academic Readiness, which is the state student test program (TEA, 2020).
- *Total cost of ownership (TCO):* A calculation of the sum of all expenses/costs associated with purchasing and using equipment, materials, and services. This TCO can include direct costs: equipment, software, hardware, or indirect costs: time loss for service, training time, and loss of connectivity (Springer, 2000).

- *Value on investment:* Intangible assets contribute heavily to an organization's performance. These intangible assets include knowledge, processes, organizational structure, and collaboration ability (US. Chamber of Commerce, 2012).

1.7 Organization of Study

This study considers a review of the literature in Chapter 2 regarding 1:1 programs (their history and operation in classrooms) along with the costs and financial view of 1:1 computing programs. The study methodology is described in Chapter 3. Chapter 4 presents the results of the research. Finally, Chapter 5 analyzes data, summarizes, draws conclusions, explains study limitations, and shares the potential future studies in this area.

1.8 Delimitations

A data collection limitation is the school districts' reporting of financial information, as each has a different process, resulting in inconsistent data outcomes. As such, there may be some cost factors that cannot be gleaned through district self-reporting. Also, there is no STAAR data relating to 2020 STAAR tests because these exams were not administered during that time due to COVID-19.

1.9 Summary

This researcher's goal was to begin a research trend towards examining the financial impact of growing school technology programs and determine whether there is a correlation with positive student outcomes. This study examined available public data to determine more significant trends and lines of research that could be detected regarding technology's total cost of ownership relative to student performance impacted by the use of computers in schools. This study represents the first step to looking at programs utilized in K-12 to start addressing systemic issues that cross demographic groups, including equitable access to technology.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature about technology in education, 1:1 computing programs, and the effect of computing on the classroom has been plentiful. In recent years, it has grown at a rate similar to the exponential growth of technology itself. There are a variety of methodologies and reviews about the general effects and outcomes found in research today. Critical to this study is the literature available on the actual financial impact and general returns seen on these initiatives. While many articles have been written on how to find funding and why funding is essential, few studies examined the financial aspects of 1:1 computing programs and whether the districts that implement them have returns on investment (ROI) from these programs. This chapter provides the context for a study with the possibility of obtaining a measurable ROI for 1:1 computing programs. Firstly, literature about technology in education is examined, followed by a review of 1:1 computing programs. Thirdly, the review examines the current funding and financial aspects of 1:1 computing programs. Fourthly, the review explores how to measure these programs' returns in keeping with academic and business metrics. Finally, this chapter examined the literature on the returns, gains, and financial aspects of 1:1 computing programs.

2.2 Technology in Education

Technology has been incorporated into classroom instruction since the early 20th Century by introducing film and radio (Cuban, 1993; Molenda, 2022). However, it was not until the 1980s and 1990s that school reforms began utilizing computers to assist learning (Cuban, 1993: Pregowska et al., 2021). Early computer teaching programs focused on rote memorization to facilitate lower-level cognitive skills (Flick & Bell, 2000). However, with technological advances and gaming, higher-level cognitive skills such as critical thinking can now be developed more effectively (Jonassen, 2000; Moseikina et al., 2022). The concept of educational technology soon emerged as a specific element of pedagogy (Delgado et al., 2015). Educational technology encompasses hardware and software supporting educational goals, including desktop and laptop computers, tablets, smartphones, smart whiteboards, and internet- or cloud-based educational software (Ross, 2020). Education applications have become increasingly prevalent, constantly creating, and updating new ones (Huang, 2019). As a result, the number of investments made in purchasing digital devices for students has increased dramatically (Huang, 2019; Stokes et al., 2003), leading to rapid growth in the use of technology in K-12 classrooms (Huang, 2019; Ringstaff & Kelley, 2002; Ross, 2020).

2.2.1 Technology Spending in Education

The United States Government allocated approximately $1.3 trillion towards education in 2010, with K-12 education accounting for $625 billion of the cost (COE, 2011). In addition, the 2021 American Rescue Plan Act included $122 billion in Elementary and Secondary School Emergency Relief (ESSER) funds to help schools reopen safely and address the impact of COVID-19 on students (Public Law 117 – 2). E-learning expenditures at the K-12 level constituted a minute portion (0.5%) of total education spending; however, the expenditures in this market are on the rise. In 2013, the government increased its education spending to $1.5 trillion, with K-12 education accounting for $718 billion and K-12 e-learning accounting for 0.7% of the total K-12 education budget (Delgado et al., 2015). As a result, the for-profit education technology market has significantly grown (Richards & Struminger, 2013; Schmidt & Srivastava, 2019). According to the Software & Information Technology and Learning Industry Association, 122 education technology vendors reported a combined revenue of $2.4 billion, a

2.7% increase from 2012 to 2013 and a 6.4% increase from 2010 (Richards & Struminger, 2013). In the United States, $9 billion is invested annually in school hardware and software technology (New Schools, 2017).

2.2.2 Technology Access and Knowledge

Despite persistent inequalities in technology access, most students in the United States can now connect to the internet from home or school (Chandra et al., 2020; Pearson, 2013; U.S. Census Bureau, 2020). With the prevalence of internet access and computer technology in and out of the classroom (Gray et al., 2010; Vogels et al., 2020), educational technology has become as ubiquitous in schools as desks. Alongside the widespread availability of physical technology for students, educational groups and programs have emphasized the importance of technology literacy.

Two decades ago, “A Nation at Risk” (1983) recommended that high school graduates should be required to have a basic knowledge of computer science. Since then, American schools have made significant advancements in their technological capabilities, including 1:1 programs, infrastructure, professional development, and technical support (Dickard, 2003; Thomas, 2016). The No Child Left Behind Act of 2001 (NCLB) called for eighth-grade students to be technologically literate and cited technology as a critical tool for teaching and learning across all subjects. The National Commission on Excellence in Education also produced a report specifying that high school graduates should have a level of understanding of computers as information, computation, and communication devices, as well as the ability to use them for personal, work-related, and study purposes (National Commission on Excellence in Education, 1983). These calls for knowledge and requirements paved the way for different technology models in K-12 schools, such as 1:1 computing programs (Culp et al., 2005; Machusky &

Herbet, 2022). Texas, for example, utilized the Long-Range Plan for Technology from 2006-2020 to support education guidelines, student standards, and educational technology purchases (TEA, 2020). The proposals for the 1:1 computing programs by independent school districts in Texas cited the two main goals as technology literacy and curriculum integration.

2.2.3 Defining 1:1 Computing Programs

The concept of a 1:1 computing programs is straightforward - one device for each individual. However, every program is unique in its expectations, funding, and implementation model, including variations in hardware, software, networking, teacher training, professional development, and program support (Machusky & Herbet 2022; Ross 2020). Similarly, research articles exploring the subject have distinct expectations, methodological approaches, and outcomes. The first initiatives in the U.S. appeared in the mid-1990s, with Microsoft's Anytime, Anywhere Learning Program being the most visible (Håkansson & Lindqvist, 2019;). Schools and districts implemented programs in which students could lease or buy the laptop computers they and their teachers were expected to use in school. In recent years, Apple Computer, Inc. has become more involved in this area, and despite the high estimated total cost of ownership of laptop computers, entire districts and even states continue to invest in initiatives designed to provide every student in certain grade levels with a laptop computer (Ross, 2020).

Implementing large-scale 1:1 computing programs in more developed nations, such as the One Laptop Per Child program (OLPC), Intel, and India initiatives, has been built upon the success of previous programs started by schools and governments (Islam & Anderson, 2016). The popularity of these initiatives is evident, with many countries and states implementing similar programs over the years. The Apple Classrooms of Tomorrow Project, as far back as 1986, provided students and teachers with two computers – one for home and one for school

(Dwyer, 1994). The earliest known 1:1 computing program was possibly the Ladies' Methodist College in Australia in 1989 (Bebell, 2005). Over the past two decades, the United States has seen significant growth in 1:1 computing programs, with states like Maine deploying statewide since 2001 (Gritter & Silvernail, 2011; Islam & Andersson, 2016). In Iowa, before COVID, approximately 140 school districts - over a third of the state's total - gave their students a computer, while in Australia, New South Wales worked with Lenovo to distribute laptops to every student in Years 9-12 (New South Wales Government 2012). Small pilots and full-grade 1:1 computing programs involving tablets, netbooks, or laptops were implemented by countless schools and districts worldwide, and this trend continues to proliferate (Islam & Andersson, 2016; Ross, 2020). Chromebooks have contributed to the growth of 1:1 computing programs and become synonymous with these initiatives due to their affordability. Chromebook sales surpassed 51% in the K-12 market nationwide in the third quarter of 2016 (Schwartz, 2016). These devices have become increasingly popular, particularly in districts with limited financial resources, seeing 50% of American teachers utilizing a 1:1 environment in 2017 (Singer, 2017). COVID has further accelerated the demand for 1:1 computing programs due to the schools' requirement to go virtual. Still, 41% of students from lower-income families still lack access to suitable devices for distance education (Vogels, 2021). As a result, the 1:1 response to COVID is likely to have a long-term impact on the usage and deployment of devices for students (Chandra et al., 2020).

2.2.4 1:1 Computing Program Scale

Although 1:1 computing programs are becoming more common worldwide, there is a lack of knowledge regarding the prevalence, scale, and scope of such programs (Islam & Grönlund, 2016). The definition of "1:1 computing" is not agreed upon universally. While it refers to the ratio of devices to the number of students, several variables must be considered. The term “computing device” is vague and can include laptops, netbooks, tablets, and even smartphones. Penuel (2006) proposes that the device should be a “portable laptop computer” with wireless network access, while Fleischer (2011) emphasizes that the same person should always have access to the computer with identical settings, programs, and folder structure.

The educational ICT community often disagrees with the minimum requirements for a 1:1 computing program (Quick, 2010; Solomon, 2005). Some educators believe that a program cannot be considered 1:1 unless students have direct access to devices at all times, including evenings and weekends (Oppenheimer, 2003; Papert, 1996), while others feel that daily access to a set of classroom computers is sufficient (Hover & Wise, 2022; Solomon, 2005). Bring Your Own Technology (BYOT) or Bring Your Own Device (BYOD) initiatives are also a point of interest and contention (Dolan, 2016; Florence, 2012; Kay & Schellenberg, 2019), with some educators arguing that these programs do not qualify as authentic 1:1 computing programs, even if schools supplement the program with devices for lower-income students (Chou et al., 2017; Keane & Keane, 2022; McLeod, 2012; Stucke, 2012). There are various ways that a 1:1 initiative can be implemented, such as assigning devices to students for use 24/7 or retaining them in the classroom for use only during school hours. While internet connectivity was not always a feature of past 1:1 laptop implementations, it is now widely understood that all device implementations should provide internet access to students (Penuel & SRI, 2006; Pettersson, 2021). Therefore, it is essential to understand the nature of these initiatives, their prevalence in the education technology realm, and how students use these devices in the classroom.

2.3 Application of 1:1 Initiatives

Integrating digital technology into education has led to a significant increase in the adoption of 1:1 computing programs at federal, state, and district levels (Ross, 2020). However, the implementation and outcomes of these programs vary considerably. Several studies have analyzed how students use their devices in these programs, with most students using laptops for writing, note-taking, completing assignments, organizing, communicating with teachers and peers, and internet research. They primarily utilize software such as word processors, web browsers, collaborative spaces, email accounts, and chat programs, while software for teaching basic skills is less commonly used. Some programs are still in the adaptation stage of technology adoption and incorporate traditional teaching strategies with adult productivity tools. By contrast, others moved to more student-centered approaches, such as project-based learning. Due to the COVID-19 pandemic, 50% of districts planned the distribution of devices to every student, changing how devices are used regardless of the implementation level. Although there is an understanding of how students use the devices, it is still unclear whether these 1:1 computing programs have improved student success rates (Rivera Vargas & Cobo Romaní, 2020; Sancho-Gil et al., 2020).

2.3.1 Impact of 1:1 Computing Programs

Several studies have examined the impact of 1:1 computing programs on student achievement in various subjects. For example, some studies have shown that such programs lead to improvements in writing scores (Bebell & Kay, 2010; Regan et al., 2019; Silvernail & Gritter, 2007; Zheng et al., 2016) and literacy skills (Marshall Barker, 2021; Neumann & Kopcha, 2019; Suhr et al., 2010). A few studies have also found that students in 1:1 computing programs perform better in science than their peers (Berry & Wintle, 2009, Gherardi, 2020). Overall, research suggests that laptops can significantly impact student achievement in mathematics and writing and may lead to higher standardized test scores. However, the impact of the duration of the program on student performance is still unclear (Gulek & Demirtas 2005, Lei & Zhao 2007), and some argue that mobile learning has only had a minimal effect on student performance as measured by standardized testing (Males et al., 2017). Nevertheless, there is evidence to suggest that students in 1:1 computing programs achieve higher test scores and grades for writing, English language arts, mathematics, and overall grade point averages compared to those in non-1:1 computing programs (Downes & Bishop, 2015; Shapley et al., 2011; Suhr et al., 2010; Weston & Bain, 2010). Despite these findings, it is essential to note that academic outcomes are likely the result of specific program emphases rather than generic effects of technology as an intervention (Ross, 2020).

Texas developed the Texas Technology Immersion Project (TIP) to provide 1:1 laptops to 6th to 8th-grade classrooms in 23 school districts, focusing on high-need students and promoting equity to improve learning outcomes. Over three years, TIP reached more than 7,000 students (Morrison et al., 2016). An evaluation of TIP by the Texas Center for Educational Research (2008) compared 21 laptop classrooms to 21 control classrooms regarding observations, surveys of students and teachers, disciplinary data, and achievement test scores in the final project year. The evaluation found several benefits for laptop students, including increased technology skills, enhanced peer interactions during small-group activities, and reduced disciplinary problems. However, attendance declined compared to the control students. The use of technology also increased over time. An analysis of student achievement indicated that frequent use of laptops at school and home was associated with better performance on state assessments in reading and mathematics (Ross, 2020). Still, it is possible that more motivated learners, who may have been higher performing, were more likely to use the laptops frequently. Importantly, TIP helped increase access to technology and innovative learning opportunities for socioeconomically disadvantaged students, contributing to the program's original goals (Ross, 2020). Chen et al. (2018) also highlighted the potential of technology infusion in the curriculum to enhance group learning processes rather than limit them.

2.3.2 Beyond Academics in 1:1 Computing Programs

There are benefits to be gained beyond academic improvement from 1:1 computing programs, such as changes in student and teacher attitudes and behaviors. For example, several studies have shown that student engagement has increased in 1:1 computing programs (Bebell, 2005; Downes & Bishop, 2015; Milman, 2020; Nichols et al., 2020; Russell et al., 2004; Shapley et al., 2006; Warschauer & Grimes, 2005; Zucker & McGhee, 2005). For instance, a study by Bebell and Kay (2010) assessed the effect of a 1:1 computing program on five middle schools in Massachusetts and found that teachers reported students being more engaged and motivated when using laptops. In addition, teachers in 1:1 computing programs were found to utilize project-based learning and collaborative learning more frequently, reducing their use of direct instruction techniques (Dawson et al., 2008). These student and teacher behavior changes should be considered when implementing 1:1 computing programs for students.

Maine's middle-level students were involved in one of the first and largest 1:1 computing programs. As a result, the students showed increased engagement, reduced behavior referral levels, and a 7.7% increase in attendance during the program's first year (Gritter & Silvernail, 2007; Lemke & Martin, 2003; Muir et al., 2004). Other studies have reported similar positive outcomes, such as improved attendance (Lane, 2003; Texas Center for Educational Research, 2009), increased engagement (Bebell & Kay, 2010), and decreased disciplinary problems (Bebell, 2005). Additionally, the use of technology in schools was associated with improvements in students’ attitudes toward learning, self-efficacy, behavior, and technology proficiency (Burciaga, 2017; Hsieh et al., 2008; Shapley et al., 2011; Storz & Hoffman, 2013).

2.3.3 Issues with Linking Effects with 1:1 Computing Programs

Despite efforts to demonstrate a positive link between 1:1 computing and student outcomes, the results are inconsistent and complex, as noted by several studies (Andrade Johnson, 2020; Andresen, 2017; Stone, 2017; Storz & Hoffman, 2013). Although research has indicated that laptops can increase student engagement, some studies have found no significant difference in test scores (Hur & Oh, 2012) and have reported that student engagement may decrease as the novelty wears off, while the inappropriate use of laptops increases (Tsay et al., 2018; Selwyn et al., 2017). Increased access to laptops may not always lead to increased student engagement and can even result in a range of off-task behaviors (Donovan et al., 2010). Some studies have reported few or neutral effects of 1:1 computing programs (Shapley et al., 2010; Vu et al., 2019; Weston & Bain, 2010). Implementing promising interventions is not enough; implementation integrity is critical, as Johnson and Maddux (2006) noted, and technology integration requires meeting many other conditions (Gonzales & Jackson, 2020; Vu et al., 2019).

Examining current research on technology integration reveals a conflict between educational researchers and policy experts over what constitutes meaningful evidence of effectiveness (Cheung & Slavin, 2011, 2013; Escueta et al., 2017; Zheng et al., 2016). Some stakeholders view programs like ACOT or Freedom to Learn as successful if they lead to observable changes in teaching and learning, such as increasing student-centered activities, improving students’ technology skills and confidence, and providing equal access to technology (Bond & Bedenlier, 2019; Ross, 2020). However, others believe that achievement on standardized tests is the most important indicator of program success (ESRA, 2002; ESSA, 2015;

Farley-Ripple et al., 2018; Goldhaber & Ozek, 2019). States and school districts use the *Every Child Succeeds Act* of 2015 to vet and approve programs based on evidence criteria, including non-test outcomes like absenteeism and graduation rates. However, student achievement remains the predominant measure for school accountability and evaluation of program effectiveness. As a result, technology initiatives are under pressure to demonstrate achievement gains.

2.4 Cost of 1:1 and Technology Initiatives

When considering the potential academic benefits of 1:1 computing programs, examining the financial implications of providing one device for every student is crucial. These programs can vary in cost and are critical to implementing a successful program. However, there is a lack of comprehensive information on the expense of these types of programs. When analyzing the cost of a program, it is not limited to the initial purchase of the devices, training, and setting up of the digital infrastructure but also the long-term total cost of ownership (TCO). A common mistake is assuming that hardware and software are the direct expenses of technology (Delgado et al., 2015; Toyama, 2011). The TCO for information technology is typically several times the hardware cost, with a range of 5-10 times being a reasonable estimate (Toyama, 2011). In addition to hardware costs, necessary expenses include distribution, maintenance, power infrastructure, teacher training, repair and replacement, and curriculum integration (Bulman & Fairlie, 2016).

While the need for additional funding to establish an adequate level of technology and training in schools has been recognized for some time, formal budgetary recommendations did not appear until the mid-1990s (Culp et al., 2005). The PCAST Panel on Educational Technology Report recommended that five percent of all public, pre-college expenditures be devoted to technology and that cost-effectiveness analyses be undertaken to provide an important perspective on measuring technology’s impact on schools (PCAST Panel on Educational Technology, 1997). The McKinsey report also suggested that funding needs for educational technology can be met by reducing costs, reprogramming existing educational funds, and obtaining funds from new sources, both from the public and private sectors (McKinsey & Company, 1995). The Web-based Education Commission’s report recommended new public/private partnerships, sustained, long-term funding, and tax incentives to encourage investments in infrastructure (Web-based Education Commission, 2000). More recent reports stress the need for sustained funding from traditional and new sources (Blikstad-Balas & Davies, 2017).

Estimating the cost of implementing 1:1 technology projects is challenging due to varying infrastructure, training, hardware expenditures, and funding sources across districts (Gonzales & Jackson, 2020; Kay & Schellenberg, 2019; Sell et al., 2012). Budget considerations may include hardware, software, training, tech support, data storage, servers or cloud service, and insurance (Gonzales & Jackson, 2020; Nichols et al., 2020; Stover, 1999). In addition, effective 1:1 computing programs typically utilize multiple funding sources such as local tax programs, reallocated resources, per-student fees, state, and federal grants, and corporate or foundation grants (Gonzales & Jackson, 2020[Seyala et al., 2019). To secure funding from multiple sources, school districts can use various strategies, including advocating for improved outcomes to generate future tax revenues, implementing parent/caregiver and Bring Your Own Technology programs, forming consortiums with other districts, forming partnerships with businesses and community organizations, combining funds from separate budgets, and fundraising through service-learning or marketing efforts (;Topper & Lancaster, 2013).

Although bond monies can be helpful for initial purchases and refresh cycles, they are typically not allowed for teachers' professional development and other total cost of ownership expenditures, creating a lack of sustainability in this funding model (Topper & Lancaster, 2013). Relying on non-sustainable funding sources to support 1:1 computing programs can be risky, especially as external funding sources from the state or federal government decrease. One-time funding also poses challenges for future purchases, including hardware replacements and infrastructure upgrades, which could lead to financial difficulties in the long term (Stover, 1999; Topper & Lancaster, 2013). To address this issue, participating districts have explored alternative funding sources such as parent/community contributions, donations, partnerships with local organizations, incorporating technology budget items in building or school expenditures, and using federally available funds (Title I or II) for targeted student populations. Nevertheless, many districts express concerns about securing ongoing, sustainable funding for hardware, software, and infrastructure (Topper & Lancaster, 2013).

Securing funding is critical for the success of 1:1 computing programs, especially in light of reduced state budgets for K-12 schools across the United States (Dorn et al., 2020; Pelletier et al., 2022;Topper & Lancaster, 2013). Several states have significantly reduced their K-12 funding previously, including Alabama, which cut state aid for education by 18.5% over two years; Colorado, which cut funding by 6.35% for each school district, totaling $260 million; and Georgia, which reduced K-12 funding by $403 million, or 5% of the financing in 2010. (Badertscher, 2010; Center for Public Education, 2010). That cut to Georgia education funding was the largest from 2003 to 2022, demonstrating a consistent spending cut trend in Georgia and other states (Owens, 2022). Other states, such as Massachusetts, Michigan, and Pennsylvania, have also previousy experienced substantial cuts in education aid (Damron & Hall, 2010; Khadaroo & Paulson, 2010). While 1:1 computing programs may seem attractive, the cost of implementing them can be considerable. Although K-12 schools received an influx of devices due to the provisions of the CARES Act, this lump sum does not account for the long-term sustainable upkeep of the purchased devices, and educational institutions will need to continue searching for funding to sustain their 1:1 computing programs.

The FCC's E-Rate Program is one of the U.S.'s most significant education technology funding initiatives (Kayakar & Park, 2010). It aims to make telecommunications and information services more accessible to schools and libraries by providing discounts for eligible institutions on telecommunications, internet access, and internal connections, using funds from the Universal Service Fund (FCC, n.d.). The program's funding cap has risen from $3.9 billion in 2015 to $4.276 billion in 2021, intending to subsidize rather than provide all technology costs, which can range from 20% to 90% (FCC, n.d.). According to research, E-Rate school usage has been associated with positive academic gains in minority populations (Kayakar & Park, 2010). With so much funding tied to technology and 1:1 computing programs in education, the next step is to determine the value of these initiatives after understanding their costs.

2.5 Return Considerations

Education technology and 1:1 computing programs are valuable and can be evaluated based on educational gains, social value, and financial returns. To determine the value of such initiatives, many organizations, including those in the education sector, use the ROI framework (Return on Investment). This mathematical formula is a widely accepted method for measuring the benefits of an investment in terms of the returns generated.

To determine the ROI of technology or work activity, it is necessary to quantify the benefits and compare them with the costs involved, usually through division or subtraction. In the classic ROI framework, benefits and costs are expressed in monetary terms. There are two methods for calculating ROI, as described by Philips in 1997.

$$ROI = \frac{Net\ Return\ on\ Investment}{Cost\ of\ Investment} \times 100\%$$

Second Method:

$$ROI\ = \frac{FVI\ - IVI}{Cost\ of\ Investement} \times 100\%$$

where:

FVI = Final value of investment

IVI = Initial value of investment

The concept of ROI involves computing the ratio between the net program benefits and the program costs, multiplied by 100, as defined by Philips in 1997. Another way of determining ROI is to deduct costs from benefits, which better aligns with our intuition about the impact of an investment on outcomes (Horngren et al., 1997). However, the simplicity of the concept quickly fades when it comes to calculating the items in the formula. The academic ROI framework aims to maximize achievement for the greatest number of students given the available resources, and this concept is often applied intuitively by school boards and superintendents. It can be used in various contexts, such as general education, district strategy, and operations. It involves assessing total learning performance change, determining the number of students being served, and comparing these to the cost per student to achieve a given performance improvement. The formula for academic ROI, as described by Levenson in 2011, is straightforward.

$$\frac{(learning\ increase)\times(\#\ of\ students)}{\$\ spent} \qquad \text{Formula 1}$$

Measuring return on investment in education can be challenging since the benefits or results are often difficult to quantify. Education is intended to result in benefits, but these benefits may be hidden, implicit, or take a long time to manifest after graduates leave the institution. Even when benefits are explicit, assigning them a numerical value, particularly monetary, can be challenging. Similarly, calculating costs can be complicated since some costs may be hidden or not readily available, such as the frustrating costs of instructors dealing with malfunctioning technology, or the extra time spent answering incoming student emails. Furthermore, arguments about ROI calculations only become relevant after introducing a change and reliable data are available. When no reliable data is available, determining costs and benefits at the start of the decision-making process can be even more challenging. (Contin, 2010).

While some may think that ROI only applies in revenue-driven environments, it can also be used to measure savings. ROI is not limited to measuring profit but can also be used to measure improvements in productivity, quality, time savings, and direct cost reduction (Philips & Philips, 2012). Many in the education sector struggle with the absence of precise revenue numbers, but ROI impact studies can still be beneficial for identifying cost savings. When using the ROI equation, earnings can be generated in two ways: profits and direct cost savings. While profits are linked to sales and revenues, cost savings can result from improvements in work output, productivity, quality, time reduction, and direct cost reductions. In government settings, cost-saving measures can be implemented across all work groups, providing ample improvement opportunities (Philips & Philips, 2012).

To accurately calculate ROI, understanding the cost of the investment is essential. This measure includes considering the total cost of ownership (TCO) developed in the late 1980s to provide insight into the total price of computing beyond just the initial device expenses. For example, the Consortium for School Networking defined TCO as encompassing equipment costs such as laptops, servers, printers, network equipment, and software, as well as direct and indirect labor costs such as creating a support infrastructure, user support, training time, productivity losses, and device failures (COSN, 2023).

The cost of computing programs encompasses more than just the purchase of computers and network connectivity. To assess expenses properly, schools should factor in the total cost of ownership (TCO), which includes teacher and administrator training, technical support, software, equipment replacement, and other costs (Zucker & Light, 2009). In the U.S., the direct and indirect expenses per client computer for 1:1 computing programs exceed $1000 annually (Classroom TCO, n.d.; Zucker & Light, 2009), while in developing countries, the estimated per-seat cost is over $400 per year (Zucker & Light, 2009). In developing nations, hardware accounts for only one-third of the total expenses, with training, service, and support making up more than half (Gatewood, 2019; Valiente, 2010). It is misguided to compare TCO to a zero baseline since almost no policymakers recommend removing computers and internet access from schools entirely or skipping teacher training on utilizing online resources (Zucker & Light, 2009).

This research considers two main methods for determining the total cost of ownership (TCO) in organizations: dollar-based and value-based (Ellram, 1995). A dollar-based approach gathers actual cost data for each TCO element. On the other hand, a value-based TCO model incorporates both cost/dollar data and other performance data that are challenging to quantify monetarily. These intangibles are assigned point values, akin to grade book scoring, making the model intricate and requiring careful calibration to ensure accurate weighting (Ellram, 1995).

2.6 Need for the Study

Determining the cost of technology and 1:1 computing programs in education is challenging due to differences in infrastructure, training, and funding sources among K-12 school districts (Machusky & Herbet, 2022). School districts may use multiple sources to fund these initiatives, such as local tax programs, reallocating saved resources, state and federal grants, and corporate and foundation grants (Ross, 2020). However, sustained funding from traditional and new sources is necessary to establish adequate school technology and training.

One of the challenges of sustainable funding for technology is the reduction of state budgets for K-12 schools (Dorn et al., 2020; Pelletier et al., 2022). Therefore, it is crucial to consider the cost of technology and 1:1 computing programs in education and how their value can be determined. ROI can be uncomfortable to measure in education because benefits or results are often not quantifiable. TCO encompasses not only the cost of purchasing computers and connecting them to networks but also teacher and administrator training, technical support, software, equipment replacement, and other costs (Nichols et al., 2020).

Implementing computing programs in schools entails various costs beyond the purchase of the computers, including teacher and administrator training, technical support, software, and equipment replacement, among other costs (Gonzales & Jackson, 2020; Nichols et al., 2020; Stover, 1999; Zucker & Light, 2009). Therefore, the cost of technology and 1:1 computing programs in education must be carefully considered, and their value must be determined by measuring ROI and TCO. By understanding the cost and value of technology initiatives, school districts can make informed decisions about sustainable funding and ensure the successful implementation of these programs.

Determining the cost and subsequent value of 1:1 computing programs in education presents challenges due to variations in infrastructure, training, and funding sources across K-12 school districts (Machusky & Herbet 2022; Ross 2020). Despite these difficulties, school districts have utilized multiple funding sources to support these programs, including local tax programs, reallocated resources, state and federal grants, and corporate and foundation grants

(Gonzales & Jackson, 2020). These districts are spending significant budgets without clear trends demonstrating that these programs will support positive learning outcomes. Smaller state budget allocations for K-12 schools further emphasize the need for educational decision-makers to carefully consider the cost of technology programs and determine their value (Dorn et al., 2020; Pelletier et al., 2022; Topper & Lancaster, 2013). While measuring the return on investment (ROI) in education can be complex, as benefits and results are often not easily quantifiable, evaluating the total cost of ownership (TCO) is essential. TCO encompasses various expenses associated with implementing computing programs, including training, support, software, and equipment replacement. School districts can make informed decisions regarding sustainable funding by understanding the cost and value of technology initiatives. The research done in this paper has looked to assess even the basic ability to determine value based on currently available data.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This research study is an exploratory review of current data on 1:1 computing programs in Texas to determine the return on investment and total cost of ownership calculations as tools for measuring the value of these programs for schools. The primary method used to perform the research and analysis was quantitative calculations of TCO and ROI, emphasizing objective measurements and manipulation of pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or explaining a particular phenomenon (Babbie, 2010).

This research focused on the relationship between student learning outcomes that could be prescribed to technology and the financial cost of 1:1 computing programs. In addition, there is an exploratory review of the current body of research on 1:1 the effect of computing programs on student learning outcomes. Finally, these performance outcomes have been compared to the TCO of sample 1:1 computing programs implemented in Texas.

The research focused on the four largest Texas Independent school districts with branded 1:1 computer program initiatives: PowerUp (Houston ISD), iDiglearning (Dallas ISD), Learning Together Everywhere (Cypress-Fairbanks ISD), and DiGiN (Fort Worth ISD). The state assessment scores were compared from 2012 to 2022 for the Algebra STAAR EOC test and 2014 to 2022 for the English STAAR EOC. These comparisons are supplemented with high school completion rates, including graduation, continuation rate, dropouts, and GED completion. Both the state assessment data and high school completion rates were collected from the Texas

Education Agency (TEA). Utilizing the total cost of ownership (TCO) calculation should improve the analysis to assess the academic return on investment.

3.2 Research Approach Rationale

The exploratory research approach was chosen for this study due to the absence of up-to-date information on the financial impacts of 1:1 computing programs. Exploratory research is particularly well-suited for situations where the researcher aims to delve into an area that is not well-defined or lacks sufficient prior research. In this case, the scarcity of current data on the relationship between technology spending and 1:1 computing program outcomes necessitated this approach.

The selection of the four districts reviewed in this study was guided by student enrollment size in the state of Texas and their implementation of 1:1 programs within their districts. By choosing districts with comparable student populations and aligning with the Texas Education Agency’s reported student enrollment sizes, the study aims to ensure a degree of uniformity and relevance in its exploration of the relationship between technology spending and 1:1 computing program outcomes.

Exploratory research, in this context, allows the researchers to collect qualitative and quantitative data that can help in understanding the dynamics between technology spending and the effectiveness of 1:1 computing programs. The open-ended nature of exploratory research enables the investigation of various factors, such as the types of technologies implemented, the training provided to teachers and students, and the overall educational outcomes associated with these initiatives.

Moreover, the process and flexible nature of exploratory research aligns with the evolving landscape of educational technology. As technology and educational practices continue to advance, exploratory research allows the study to adapt its focus and questions to the changing environment. By uncovering insights, patterns, and potential correlations, this research serves as a foundation for subsequent, more targeted investigations and contributes valuable information to the broader educational community interested in optimizing technology use in schools.

This study drew upon the following research questions:

1. Can the student testing gains and graduation rates justify the TCO of a 1:1 computing program?
2. Can student learning outcomes show a definable correlation between positive gains and implementing 1: 1 computing programs?
3. Is there a measurable return on investment from 1:1 computing programs based on testing gains and graduation rates?

3.3 Research Context

This study focused on the four districts in Texas. Each of these districts has a 1:1 computing program that began or was piloted before COVID, providing take-home devices for all students involved.

- Houston ISD is the largest K-12 ISD in Texas, with approximately 210,001 students in 2021.
- Dallas ISD is Texas's 2nd largest K-12 ISD, with approximately 153,861 students in 2021.
- Cypress-Fairbanks ISD is Texas's 3rd largest K-12 ISD, with approximately 117,446 students in 2021.
- Fort Worth ISD is Texas's 5th largest k-12 district, serving approximately 82,891 students 2021.
- Cypress-Fairbanks ISD and Houston ISD are located in the southern area of Texas. Dallas ISD and Fort Worth ISD are located in northern Texas.

3.4 Data Collection Methods

This study did not require IRB approval due to the lack of interaction with subjects and none of the data included identifiable private information. The STAAR testing scores are secondary data which is available to the public and can be found on the Texas Education Agency site (https://tea.texas.gov/student-assessment/testing/staar/staar-aggregate-data). The data for each school within the district comparison groups were retrieved every year from 2014 to 2021. Graduation rates for each district were also retrieved from the public data available on the Texas Education Agency site (https://tea.texas.gov/reports-and-data/school-performance/accountability-research/completion-graduation-and-dropout/completion-graduation-and-dropout-data). Data used in this study relate to the cost and financial impact of 1:1 computing programs and were gathered from publicly accessible school board meetings and financial disclosures.

3.5 Data Analysis

The STAAR testing data collected underwent analysis using the IBM SPSS statistics software package. Several analytical techniques were applied, including descriptive, frequency, and correlational analyses, to discern patterns in scores spanning from 2014 to 2021. Descriptive analysis helped summarize and depict the datasets, revealing trends in gains and losses throughout the reviewed years. Frequency analysis explained score occurrences and ranges, providing insights into graduation data and STAAR scores. Correlation analysis explored the relationship between program implementation and fluctuations in scores and rates. Additionally, a one-way ANOVA was employed to scrutinize the datasets, enabling the examination of unrelated groups, such as different school districts, and facilitating comparisons between them. This evaluation was followed by a breakdown of each district's trends in STAAR scores and graduation rates against the ROI and TCO for the 1:1 computing programs. Academic ROI was calculated using the following formula:

$$ROI = \frac{(learning\ increase) \times (\#\ of\ students)}{\$\ spent}$$

The TCO determination was based on the dollar-based model, which requires gathering actual cost data for each relevant TCO element.

The research methods utilized in this study had the aim of being exploratory. The current research into 1:1 computing programs does not examine these programs' cost and measurable value. This study utilized publicly obtainable data and chosen performance measurements in other 1:1 computing program research. These methods were chosen to determine if the current data and data analysis methods in education were suitable for gleaning the cost and value of 1:1 computing programs. Building upon the research methodologies employed, the subsequent chapter delves into the analysis and presentation of the findings, shedding light on the outcomes and insights derived from the data collected.

CHAPTER 4

FINDINGS AND ANALYSIS

4.1 Introduction

This study explored the cost of 1:1 computing programs and the possible value that can be measured by implementing these programs. This study seeks to help inspire further research into 1:1 computing programs and research on a grander scale across K-12 schools and the equivalent education levels worldwide for children 6-18 years old. The results are intended to provoke exploration in this field beyond the current bodies of work, which focus on student outcomes but not cost.

The following research questions were studied:

1. Can the student testing gains and graduation rates justify the TCO of a 1:1 computing program?
2. Can student learning outcomes correlate with positive gains and implementing 1:1 computing programs?
3. Is there a measurable return on investment from 1:1 computing programs based on testing gains and graduation rates?

This chapter contains charts that track the standardized test scores of the four Texas high schools selected for review. It also contains charts that track the graduation rates for the four Texas high schools selected for review. This outcome proceeds with tables outlining the TCO for the districts, and the chapter ends with calculations of the ROI for these four districts.

Data on the STAAR scores for all four districts, including Cypress-Fairbanks, Dallas, Houston, and Fort Worth, were gathered from the TEA public website. TEA publishes all scores for districts across the state of Texas. District graduation data were also gathered from the TEA public website. Fiscal data for the districts were gathered from the National Center for Education Statistics (NCES) and school districts’ public board meeting minutes.

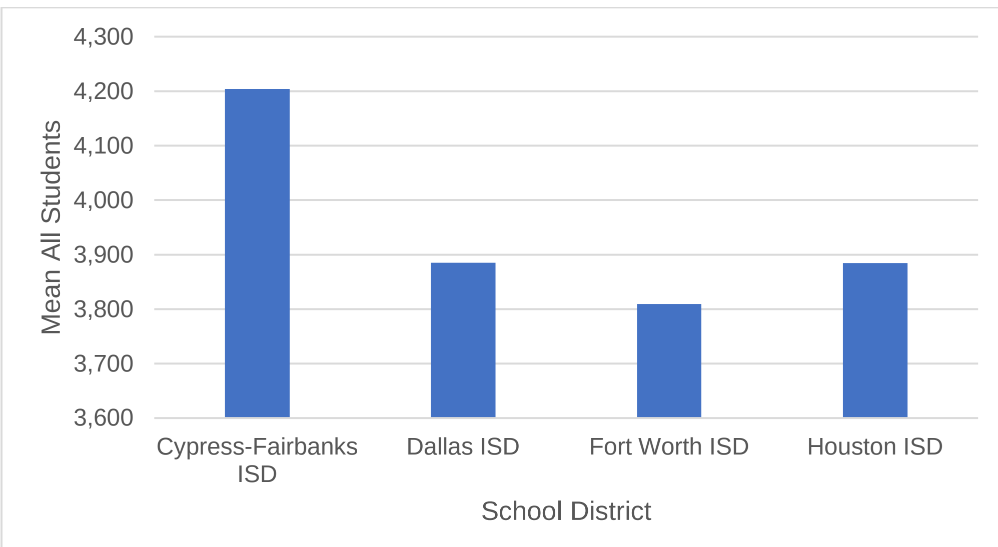
4.2 Analysis of Data on Student Testing Gains

4.2.1 All Districts

The mean algebra STAAR score for the Cypress-Fairbanks ISD, Dallas ISD, Fort Worth ISD, and Houston ISD was 3945.78 (*SD* = 197.10). Of the four school districts, Cypress-Fairbanks had the highest mean score at 4204.10 (*SD* = 146.65), followed by the Dallas ISD at 3885.30 (*SD* = 155.94), the Houston ISD at 3884.50 (*SD* = 77.50), and the Fort Worth ISD at 3809.20 (*SD* = 114.72).

Figure 1

All Students Mean Algebra Scores

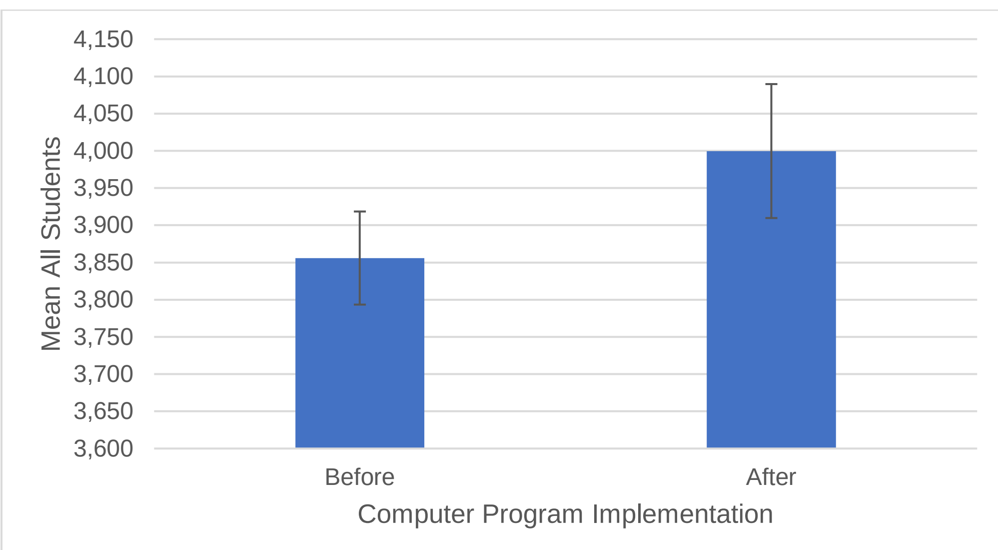


The average scores for the districts all fall within the "approaches grade level" to "meets grade level" performance labels defined by the TEA. This indicated that, on average most students in all the districts do pass the mandated threshold as required for high school graduation by the TEA. Dallas ISD, Fort Worth ISD, and Houston ISD fall under the "approaches grade level" criteria. Based on the conversion charts, this finding indicates that those students scored on average between 28% to 32% correct on the exam (https://tea.texas.gov/student-assessment/testing/staar/staar-raw-score-conversion-tables), while Cypress-Fairbanks ISD students are receiving a 55% on average on the Algebra exam, which categorized them as "meets grade level." According to the TEA, the "approaches grade level" performance label means that a student is likely to succeed in the next grade level/course and that these students generally demonstrate the ability to utilize the knowledge and skill necessary (TEA, 2017). While a "meets grade level" performance level indicates that the students have a high likelihood of success in the next grade/course (TEA, 2017). The scores in this table indicate that Cypress-Fairbanks ISD students scored higher on the Algebra STAAR exam.

A one-way ANOVA was conducted to determine if algebra STAAR scores differed for all students from 2012 to 2022 to show before versus after the computing program implementation. The test scores showed a statistically significant difference before versus after, $F(1, 38) = 7.315$, $p = .010$. In addition, mean scores were significantly higher after the program's implementation ($M = 3999.68$ ($SD = 218.00$) than before ($M = 3855.93$, $SD = 112.94$).

Figure 2

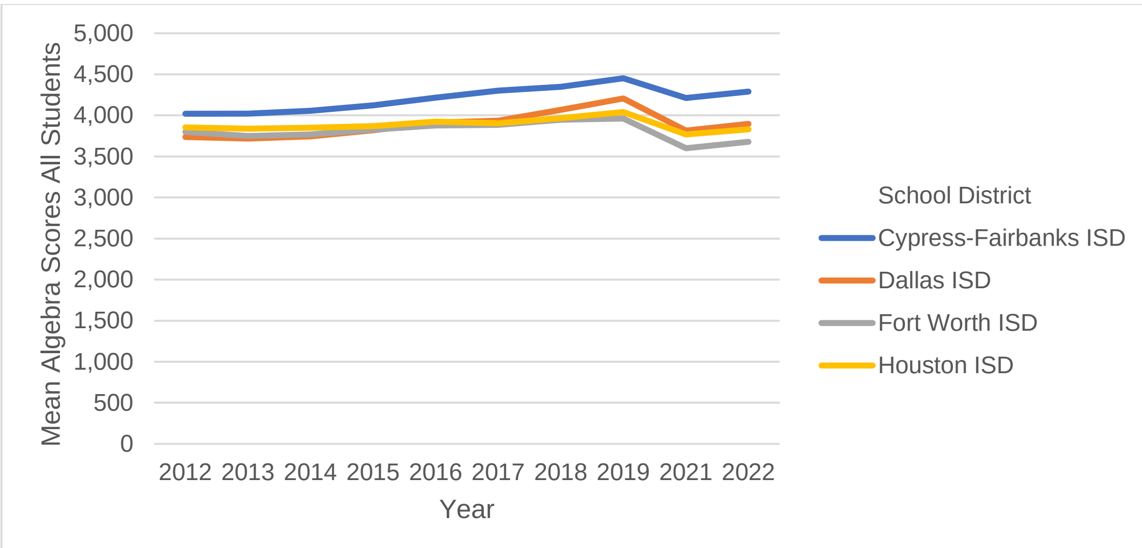
Algebra Score Differences 2012 to 2022 All Students



The p-value of .010 indicates that the observed score difference is unlikely to have occurred by chance alone. Therefore, there is strong evidence to reject the null hypothesis and conclude that the computing program implementation significantly impacted algebra STAAR scores. However, it is possible that a change in the curriculum or instructional staff could also be responsible for the outcomes since there were no controls for these confounding factors.

Figure 3

Mean Score Trends 2012 2022 All Students

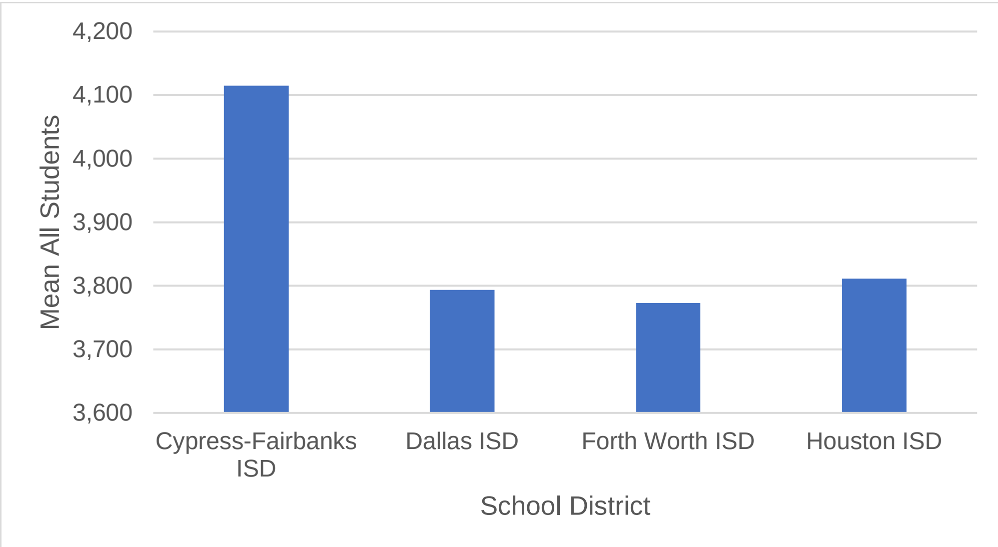


The results suggest that implementing the computing program had a statistically significant impact on algebra STAAR scores, leading to higher mean scores after introducing the program. The statistical significance of the one-way ANOVA provides strong evidence that the observed difference in scores is unlikely to be due to chance. This finding may mean the 1:1 program supported improved student performance on the algebra STAAR exam.

The mean English STAAR score for the Cypress-Fairbanks ISD, Dallas ISD, Fort Worth ISD, and Houston ISD was 3873.14 (*SD* = 146.69). Of the four school districts, Cypress-Fairbanks had the highest mean score at 4114.71 (*SD* = 63.64), followed by the Houston ISD at 3811.29 (*SD* = 28.68), the Dallas ISD at 3793.71 (*SD* = 15.42), and the Fort Worth ISD at 3772.86 (*SD* = 8.53).

Figure 4

All Students Mean English Scores

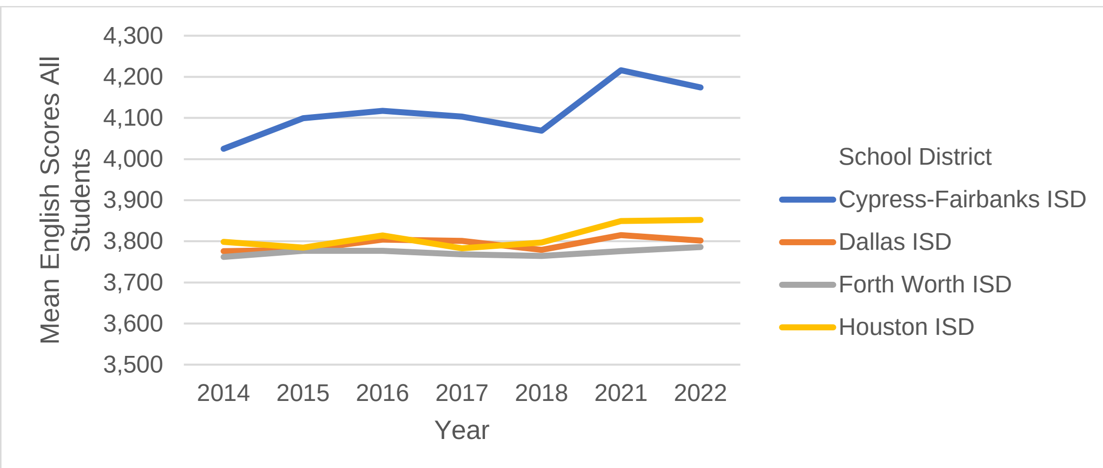


The average scores for the districts all fall within the "approaches grade level" to "meets grade level" performance labels defined by the TEA. This indicated that, on average most students in all the districts do pass the mandated threshold as required for high school graduation by the TEA. Dallas ISD, Fort Worth ISD, and Houston ISD fall under the "approaches grade level" criteria, indicating that those students received between a 40% to 44% correct on the exam (https://tea.tas.gov/student-assessment/testing/staar/staar-raw-score-conversion-tables), while Cypress-Fairbanks ISD students are receiving a 65% on average on the English I exam, which categorizes them as "meets grade level." According to the TEA, an "approaches grade level" performance label means that a student is likely to succeed in the next grade level/course and that these students generally demonstrate the ability to utilize the knowledge and skill necessary (TEA, 2017). A "meets grade level" performance level indicates that the students will likely succeed in the next grade/course (TEA, 2017). This table indicates that Cypress-Fairbanks ISD students scored higher on the English I STAAR exam than the comparison districts.

A one-way ANOVA was conducted to determine if English STAAR scores differed for all students from 2014 to 2022 to show before versus after the computing program's implementation. The test scores were not statistically significantly different before versus after implementing the 1:1 computing program, R$F(1, 26) = 3.640$, $p = .068$. The p-value of .068 is greater than the typical significance level of 0.05. This finding indicates that the observed difference in scores could reasonably be explained by chance or other factors not controlled for in this study, and there is insufficient evidence to reject the null hypothesis.

Figure 5

Mean Score Trends 2014 2022 All Students' English



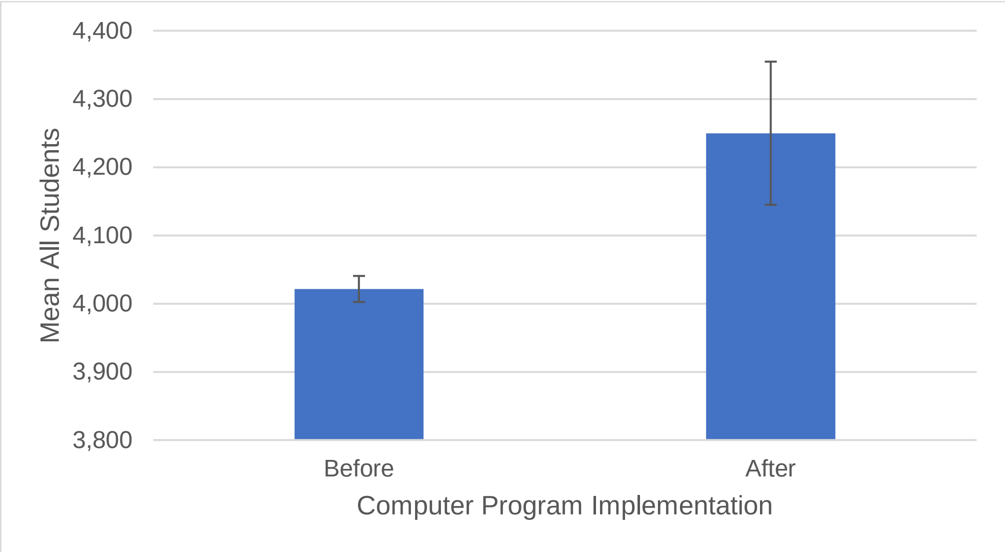
The analysis indicates no statistically significant difference in English STAAR scores before versus after the implementation of the laptop initiative. This finding suggests that the initiative did not have a statistically significant effect on student performance in English. However, it is essential to consider other factors that may have influenced the results and to interpret the findings within the study's specific context.

4.2.2 Cypress-Fairbanks ISD

A one-way ANOVA was conducted to determine if algebra STAAR scores differed for all Cypress-Fairbanks ISD students before versus after the implementation of the computer program. The test scores were statistically significantly different before versus after, $F(1, 8) = 6.052$, $p = .039$. In addition, mean scores were statistically significantly higher after the program's implementation ($M = 4249.75$ ($SD = 125.47$) than before ($M = 4021.50$, $SD = 2.12$). The p-value of .039 is smaller than the typical significance level of 0.05. This outcome indicates that the observed score difference is unlikely to have occurred by chance alone, providing evidence to reject the null hypothesis.

Figure 6

Algebra Score Differences 2012 to 2022 Cypress-Fairbanks



This suggests that implementing the computer program statistically significantly affected algebra STAAR scores among Cypress-Fairbanks ISD students. The observed increase in mean scores provides evidence of the program's effectiveness in improving student performance. This likely indicates that the program has effectively improved student performance in the algebra STAAR exam.

Data were unavailable to properly assess Cypress-Fairbanks ISD trends before and after the computer program implementation and over time. Their 1:1 computing program started in

2014. Before 2015, the STAAR end-of-course exam for English I consisted of two tests reading and writing. The 2015 STAAR EOC English I was combined into a single test (TEA, 2022).

4.2.3 Dallas ISD

A one-way ANOVAs was conducted to determine if algebra STAAR scores differed for all Dallas ISD students before and after the computer program's implementation. The test scores were not statistically significantly different before versus after, $F(1, 8) = 1.406$, $p = .270$. This indicates no statistically significant difference in algebra STAAR scores before versus after implementing the computer program among Dallas ISD students. This suggests that the program did not have a noticeable effect on student performance in algebra.

A one-way ANOVAs was conducted to determine if English STAAR scores differed for all Dallas ISD students before and after the computer program's implementation. The test scores were not statistically significantly different before versus after, $F(1, 5) = 3.754$, $p = .110$. The analysis indicates no statistically significant difference in English STAAR scores before versus after the computer program implementation among Dallas ISD students. This suggests that the program did not have a noticeable effect on student performance in English.

4.2.4 Fort Worth ISD

A one-way ANOVAs was conducted to determine if algebra STAAR scores differed for all Fort Worth ISD students before and after the computer program's implementation. The test scores were not statistically significantly different before versus after, $F(1, 8) = 0.406$, $p = .542$. This shows no statistically significant difference in algebra STAAR scores before versus after implementing the computer program among Fort Worth ISD students. This suggests that the program did not have a noticeable effect on student performance in algebra.

A one-way ANOVAs was conducted to determine if English STAAR scores differed for all Fort Worth ISD students before and after the computer program's implementation. The test scores were not statistically significantly different before versus after, $F(1, 5) = 2.297$, $p = .190$. This indicates no statistically significant difference in English STAAR scores before versus after implementing the computer program among Fort Worth ISD students. This suggests that the program did not have a noticeable effect on student performance in English.

4.2.5 Houston ISD

A one-way ANOVAs was conducted to determine if algebra STAAR scores differed for all Houston ISD students before and after the computer program's implementation. The test scores were not statistically significantly different before versus after, $F(1, 8) = 0.964$, $p = .355$. The analysis indicates no statistically significant difference in algebra STAAR scores before versus after the computer program implementation among Houston ISD students. This suggests that the program did not have a noticeable effect on student performance in algebra.

A one-way ANOVAs was conducted to determine if English STAAR scores differed for all Houston ISD students before and after the computer program's implementation. The test scores were not statistically significantly different before versus after, $F(1, 5) = 0.185$, $p = .685$. This shows no statistically significant difference in English STAAR scores before versus after the computer program implementation among Houston ISD students. This suggests that the program did not have a noticeable effect on student performance in English.

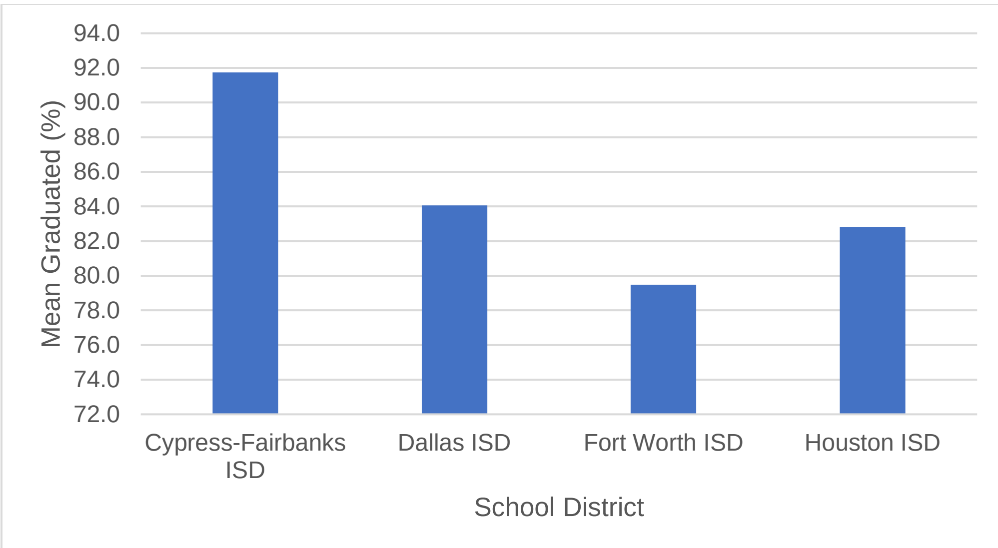
4.3 Analysis of Graduation Rates

4.3.1 All Students Mean

The mean graduation rate for the Cypress-Fairbanks ISD, Dallas ISD, Fort Worth ISD, and Houston ISD was 84.53% (*SD* = 5.10%). Out of the four school districts, Cypress-Fairbanks had the highest mean rate at 91.75% (*SD* = 1.12%,) followed by the Dallas ISD at 84.06% (*SD* = 3.39%), the Houston ISD at 82.83% (*SD* = 2.73%), and the Fort Worth ISD at 79.49% (*SD* = 1.74%).

Figure 7

Mean Graduation Rates 2011 2021 All Students

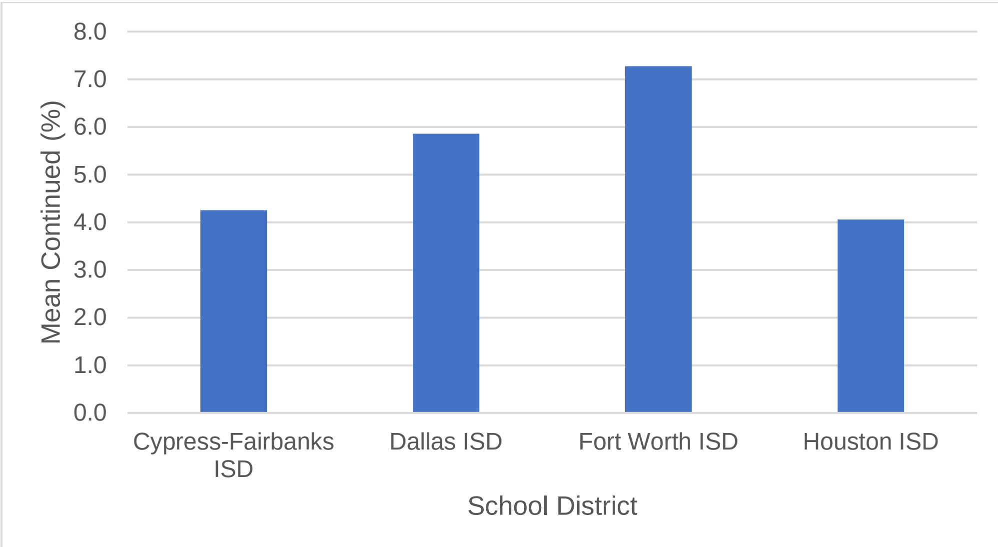


The data included variations in graduation rates among the four school districts. Cypress-Fairbanks ISD had the highest mean graduation rate, followed by Dallas ISD, Houston ISD, and Fort Worth ISD. The standard deviations provided information about the variability or spread of the graduation rates within each district. This outcome served as a benchmark against which individual district rates can be evaluated.

The mean continued rate for the Cypress-Fairbanks ISD, Dallas ISD, Fort Worth ISD, and Houston ISD was 5.36% (*SD* = 1.82%). Out of the four school districts, Fort Worth had the highest mean rate at 7.27% (*SD* = 1.36%), followed by the Dallas ISD at 5.86% (*SD* = 1.92%), the Cypress-Fairbanks ISD at 4.26% (*SD* = 0.90%), and the Houston ISD at 4.06% (*SD* = 6.60%).

Figure 8

Mean Continued Rate 2011 to 2021 All Students



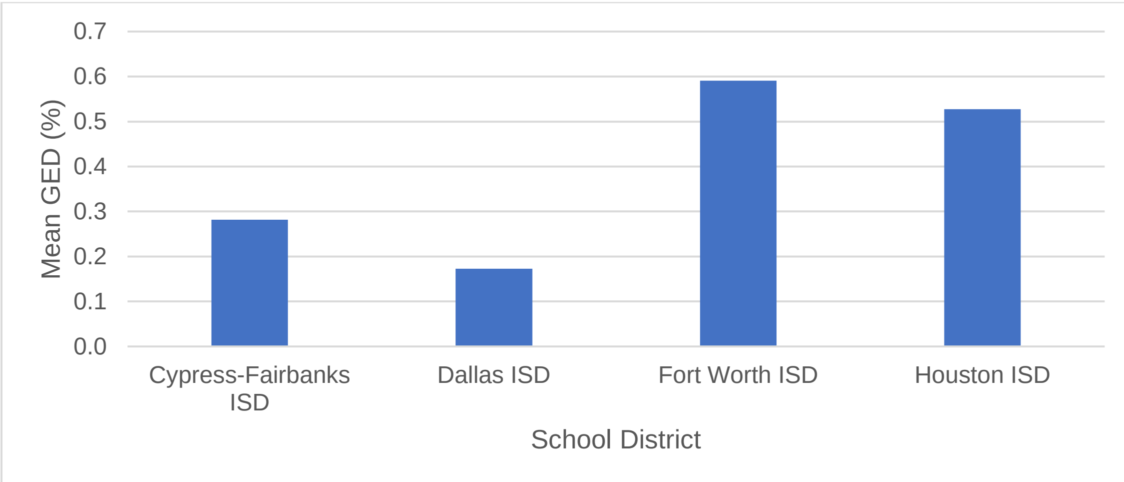
There were variations in the mean continued rates among the four school districts. Fort Worth ISD has the highest mean continued rate, followed by Dallas ISD, Cypress-Fairbanks ISD, and Houston ISD. The standard deviations provide information about the variability or spread of the continued rates within each district. The mean provides a point of reference to understand the significance of the individual district rates.

The mean GED rate for the Cypress-Fairbanks ISD, Dallas ISD, Fort Worth ISD, and Houston ISD was 0.39% (*SD* = 0.25%). Out of the four school districts, Fort Worth had the highest mean rate at 0.59% (*SD* = 0.14%), followed by the Houston ISD at 0.53% (*SD* = 0.30%), the Cypress-Fairbanks ISD at 0.28% (*SD* = 0.14%), and the Dallas ISD at 0.17% (*SD* = 0.14%).

The analysis shows variations in the mean GED rates among the four school districts. Fort Worth ISD has the highest mean GED rate, followed by Houston ISD, Cypress-Fairbanks ISD, and Dallas ISD. The standard deviations provide information about the variability or spread of the GED rates within each district. These findings provide insights into the differences in the rates of students obtaining GED credentials across the districts.

Figure 9

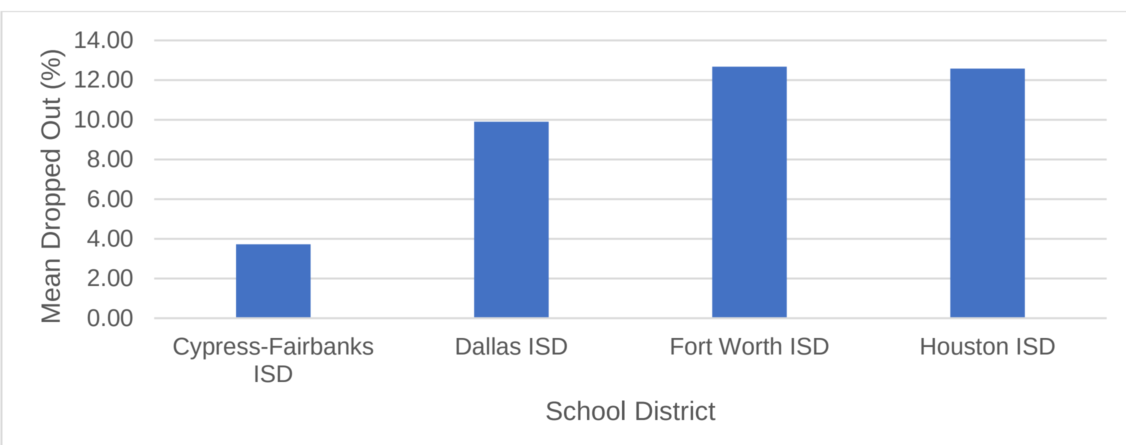
Mean GED Rate 2011 to 2021 All Students



The mean dropout rate for the Cypress-Fairbanks ISD, Dallas ISD, Fort Worth ISD, and Houston ISD was 9.72% (*SD* = 3.92%). Out of the four school districts, Fort Worth had the highest mean rate at 12.67% (*SD* = 0.87%), followed by the Houston ISD at 12.58% (*SD* = 2.01%), the Dallas ISD at 9.91% (*SD* = 1.71%), and the Cypress-Fairbanks ISD at 3.72% (*SD* = 0.51%).

Figure 10

Mean Dropout Rate 2011 to 2021 All Students



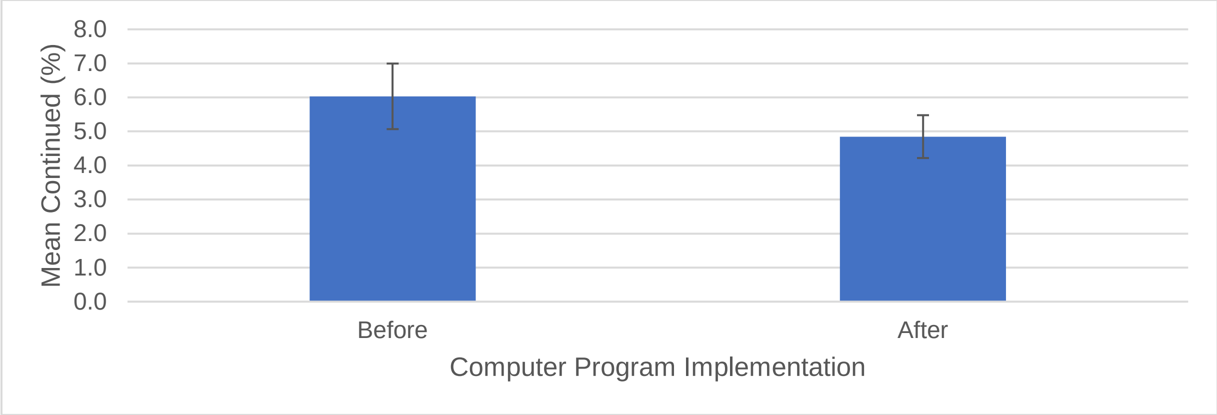
This finding indicates variations in the mean dropout rates among the four school districts. Fort Worth ISD has the highest mean dropout rate, followed by Houston ISD, Dallas ISD, and Cypress-Fairbanks ISD. The standard deviations provide information about the variability or spread of the dropout rates within each district. These findings highlight the differences in dropout rates and suggest varying challenges related to student retention across the districts.

4.3.2 All Students' Rates Before and After Implementation

A one-way ANOVA was conducted to determine if graduation rates differed for all students from 2011 to 2021 before versus after the computing program implementation. The test scores were not statistically significantly different before versus after, $F(1, 42) = 2.096$, $p = .155$. The p-value was more significant than the conventional threshold of .05, which suggested that any observed differences in graduation rates between the two periods could be due to random variation or chance rather than the impact of the computing program. This indicates that the program may not have had a significant influence on the graduation rates

Figure 11

Graduation Rate Difference for All Students 2011 to 2021



A one-way ANOVA was conducted to determine if continued rates differed for all students from 2011 to 2021 before versus after the computing program implementation. The test scores were statistically significantly different before versus after, $F(1, 42) = 4.975$, $p = .031$. Mean scores were significantly higher before program implementation. ($M = 6.03\%$, $SD = 2.00\%$) than after ($M = 4.85\%$, $SD = 1.53\%$).

The significant p-value showed that observed differences in continued rates between the two periods are unlikely to be due to random variation or chance. Specifically, the mean continued rate before program implementation was 6.03% with a standard deviation of 2.00%, while after program implementation, the mean continued rate was 4.85% with a standard deviation of 1.53%. The mean scores were higher before the program. This outcome suggests that the programs may not have significantly influenced GED rates during that period, indicating a potential negative impact of the program on students' continuation of education.

A one-way ANOVA was conducted to determine if GED rates differed for all students from 2011 to 2021 before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 42) = 2.221$, $p = .144$. The p-value suggests that any observed differences in GED rates between the two periods could be due to random variation or chance rather than the impact of the computing programs.

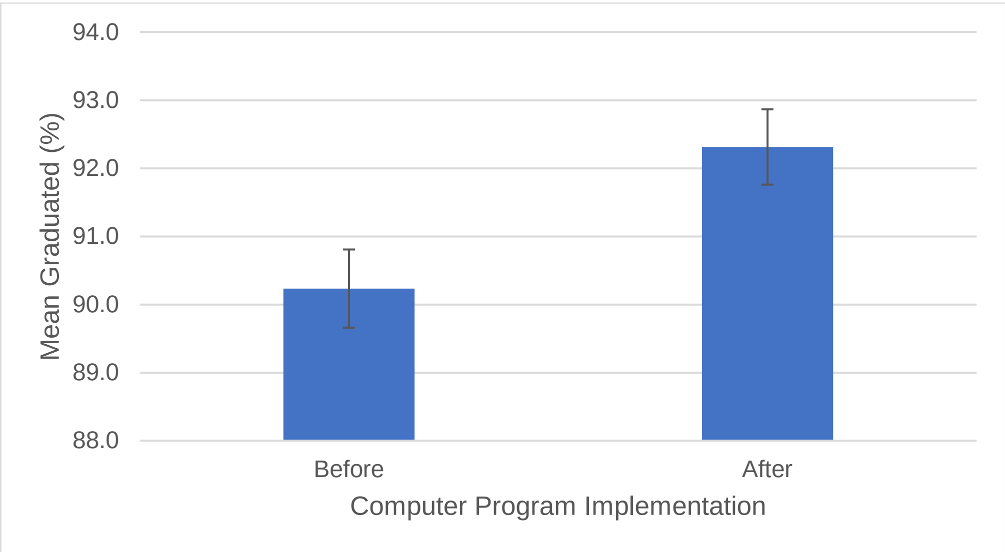
A one-way ANOVA was conducted to determine if all students' dropout rates differed from 2011 to 2021 before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 42) = 0.552$, $p = .462$. This did not find a statistically significant difference in dropout rates before and after the implementation of the computing programs from 2011 to 2021. This finding suggests that the programs may not have significantly influenced dropout rates during that period.

4.3.3 Cypress-Fairbanks ISD

A one-way ANOVA was conducted to determine if graduation rates differed for Cypress-Fairbanks ISD students before versus after the implementation of the computing programs. The test scores were statistically significantly different before versus after, $F(1, 9) = 26.732$, $p < .001$. Mean scores were significantly higher after program implementation (M = 992.31%, SD = 0.66%) than before (M = 90.23%, SD = 0.23%).

Figure 12

Graduation Rate Differences 2011 to 2022 Cypress-Fairbanks



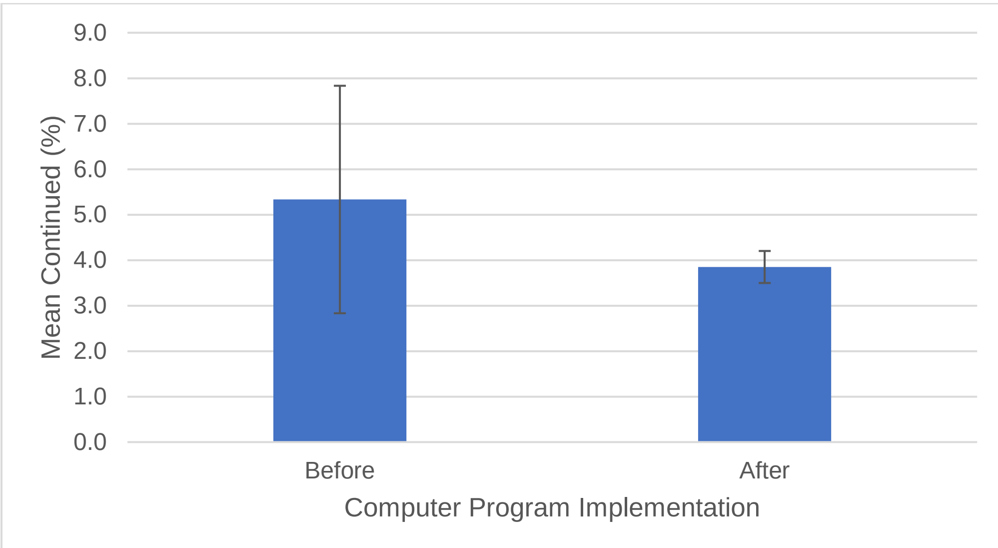
After implementing the computing program, the analysis found a statistically significant increase in graduation rates for Cypress-Fairbanks ISD students. The p-value showed that the differences in graduation rates showed an impact resulting from the program's implementation. There was an indication of an improvement in graduation rates due to the program.

A one-way ANOVA was conducted to determine if continued rates differed for Cypress-Fairbanks ISD students before versus after the implementation of the computing programs. The test scores were statistically significantly different before versus after, $F(1, 9) = 13.226$, $p = .005$.

Mean scores were significantly higher before program implementation (*M* = 5.33%, *SD* = 1.01%) than after (*M* = 3.85%, *SD* = 0.42%).

Figure 13

Continued Rate Differences 2011 to 2021 Cypress-Fairbanks



Results indicate that there was a statistically significant difference in continued rates before versus after the implementation of the computing programs. This finding is supported by the F-statistic of 13.226 and a p-value of .005. This result suggests that the observed difference in continued rates between the two periods is unlikely due to random variation or chance and is more likely to be associated with the impact of the computing programs. The analysis indicated that implementing the computing programs significantly impacted continued rates for Cypress-Fairbanks ISD students.

A one-way ANOVA was conducted to determine if GED rates differed for Cypress-Fairbanks ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 3.737$, $p =$ .085. The p-value of .085 is greater than the conventional threshold of .05, suggesting that the observed difference in GED rates between the two periods could be due to random variation or chance. This gives insufficient evidence to conclude that the implementation of the computing programs had a significant impact on GED rates for Cypress-Fairbanks ISD students.

A one-way ANOVA was conducted to determine if dropout rates differed for Cypress-Fairbanks ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 1.027$, $p = .337$. The p-value of .337 is greater than the conventional threshold of .05, suggesting that the observed difference in dropout rates between the two periods could be due to random variation or chance. This indicated no significant difference in dropout rates before and after the computing program implementation.

4.3.4 Dallas ISD

A one-way ANOVA was conducted to determine if graduation rates differed for Dallas ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 1.118$, $p = .318$. The p-value of .318 is greater than the conventional threshold of .05, suggesting that the observed difference in graduation rates between the two periods could be due to random variation or chance. This indicated no significant difference in graduation rates before and after the computing program implementation.

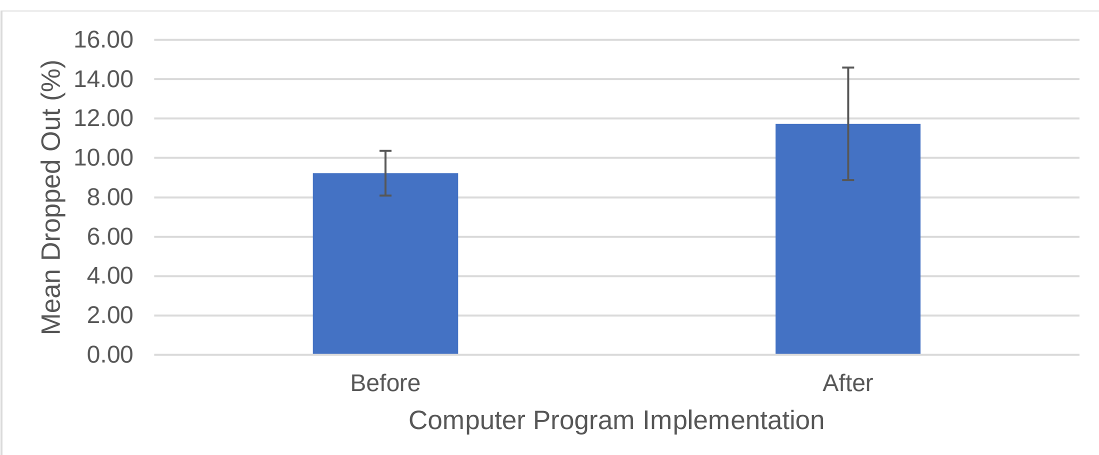
A one-way ANOVA was conducted to determine if continued rates differed for Dallas ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 0.00$, $p = .983$. The p-value of .983 is greater than the conventional threshold of .05, suggesting that the observed difference in continued rates between the two periods could be due to random variation or chance. This gives insufficient evidence to conclude that the implementation of the computing programs had a significant impact on continued rates for Cypress-Fairbanks ISD students.

A one-way ANOVA was conducted to determine if GED rates differed for Dallas ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 0.295$, $p = .600$. The p-value of .600 is greater than the conventional threshold of .05, suggesting that the observed difference in GED rates between the two periods could be due to random variation or chance. This indicated no significant difference in GED rates before and after the computing program implementation.

A one-way ANOVA was conducted to determine if dropout rates were different for Dallas ISD students before versus after the implementation of the computing programs. The test scores were statistically significantly different before versus after, $F(1, 9) = 7.929$, $p = .020$. In addition, mean scores were significantly higher after the program's implementation (M = 11.73%, SD = 1.15%) than before (M = 9.23%, SD = 1.36%).

Figure 14

Dropout Rate Differences 2011 to 2021 Dallas



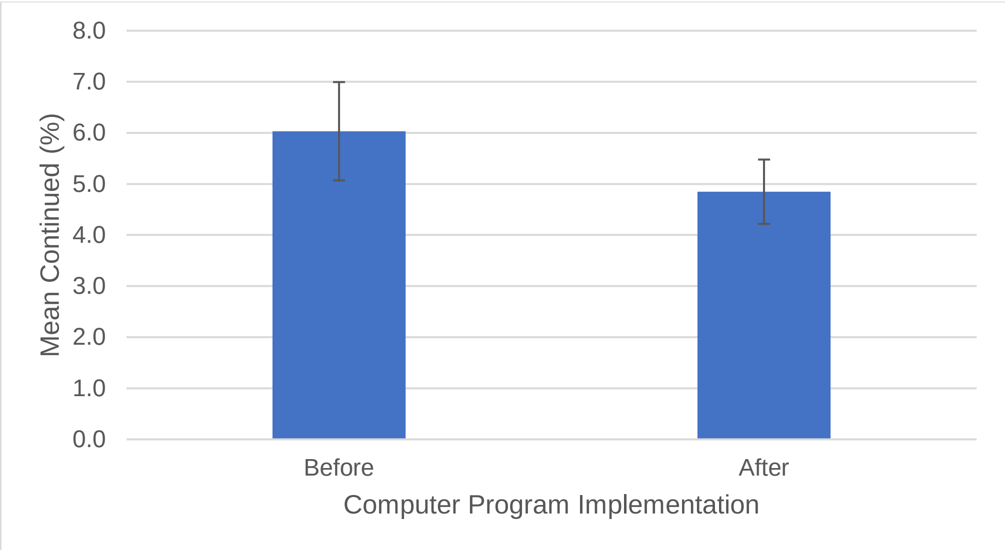
The analysis found a statistically significant difference in dropout rates for Dallas ISD students before and after implementing the computing programs. The p-value of .020 was less than the conventional threshold of .05, suggesting that the observed difference in dropout rates between the two periods is unlikely due to random chance. The mean dropout rate increased after the program's implementation, suggesting a potential negative impact of the programs on dropout rates.

4.3.5 Fort Worth ISD

A one-way ANOVA was conducted to determine if graduation rates differed for Fort Worth ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 2.096$, $p = .155$. The analysis did not find a statistically significant difference in graduation rates for Fort Worth ISD students before and after implementing the computing programs. This finding indicated that the programs did not significantly impact graduation rates.

Figure 15

Continued Rate Differences 2011 to 2021 Fort Worth



A one-way ANOVA was conducted to determine if continuation rates differed for Fort Worth ISD students before versus after the implementation of the computing programs. The test scores were statistically significantly different before versus after, $F(1, 9) = 4.975$, $p = .031$. In addition, mean scores were significantly higher before the program's implementation (M = 6.03%, SD = 2.00%) than after (M = 4.85%, SD = 1.53%).

The data showed a statistically significant difference in continuation rates for Fort Worth ISD students before and after implementing the computing programs. This indicates that the programs may have positively impacted continuation rates. The p-value of .031 is less than the conventional threshold of .05, suggesting that the observed difference in continuation rates between the two periods is unlikely due to random chance.

A one-way ANOVA was conducted to determine whether GED rates differed for Fort Worth ISD students before and after implementing the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 2.221$, $p = .144$. The p-value of .144 is greater than the conventional threshold of .05, suggesting that the observed difference in GED rates between the two periods could be due to random variation or chance. This indicated no significant difference in GED rates before and after the computing program implementation.

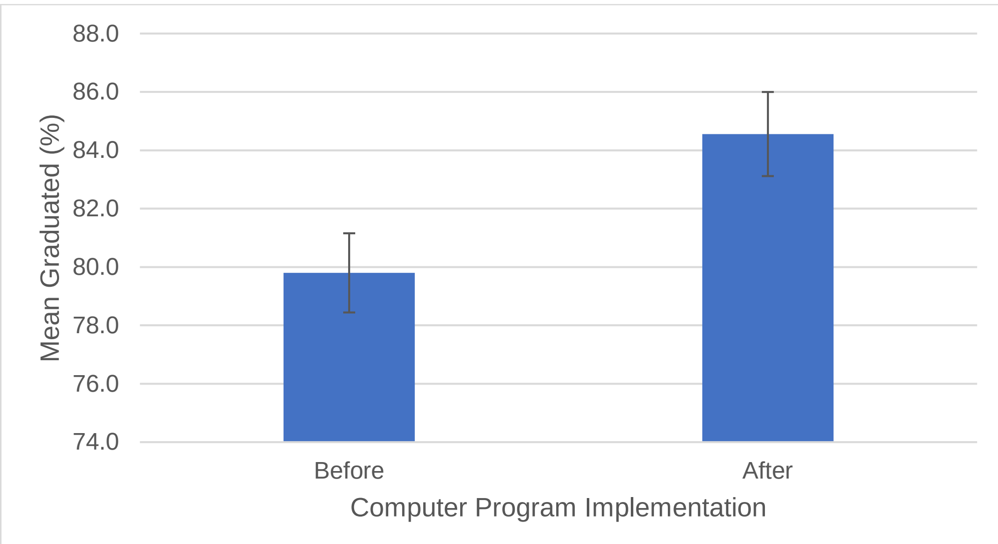
A one-way ANOVA was conducted to determine if dropout rates differed for Fort Worth ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 0.552$, $p = .462$. The analysis did not find a statistically significant difference in dropout rates for Fort Worth ISD students before and after implementing the computing programs. This showed that the programs did not statistically significantly impact dropout rates.

4.3.6 Houston ISD

A one-way ANOVA was conducted to determine if graduation rates differed for Houston ISD students before versus after the implementation of the computing programs. The test scores were statistically significantly different before versus after, $F(1, 9) = 30.976$, $p < .001$. In addition, means were significantly higher after the program's implementation ($M = 84.56\%$, $SD = 1.56\%$) than before ($M = 79.80\%$, $SD = 0.85\%$).

Figure 16

Graduation Rate Differences 2011 to 2021 Houston



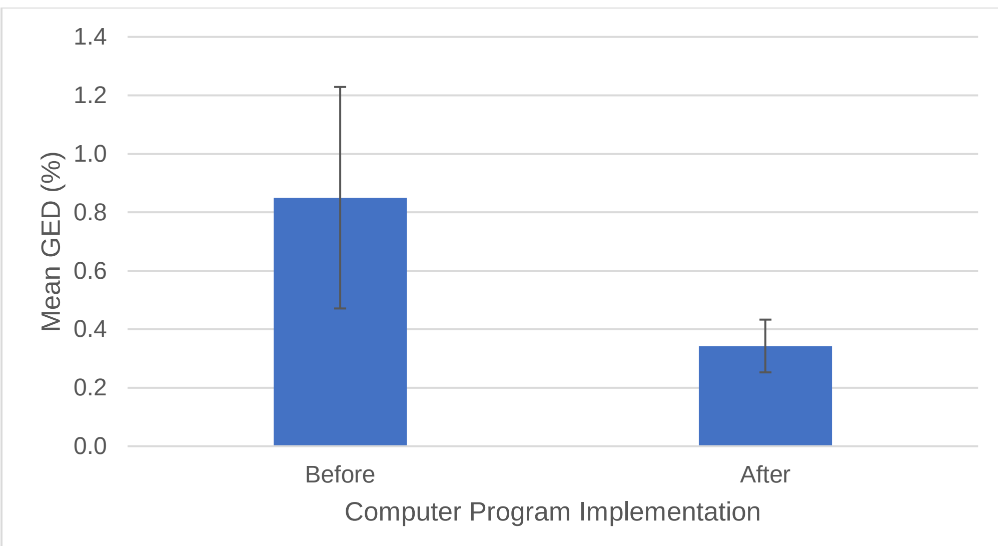
The analysis found a statistically significant difference in graduation rates for Houston ISD students before and after implementing the computing programs. The p-value of <.001 was less than the conventional threshold of .05, suggesting that the observed difference in graduation rates between the two periods is unlikely due to random chance. The mean graduation rate increased after the program's implementation, suggesting a potential positive impact of the programs on graduation rates.

A one-way ANOVA was conducted to determine if continuation rates differed for Houston ISD students before versus after the implementation of the computing programs. The test scores were not statistically significantly different before versus after, $F(1, 9) = 3.110$, $p = .112$. The lack of statistical significance indicates that any difference in continuation rates observed between the two periods could be due to random chance or other factors unrelated to implementing the computing programs.

A one-way ANOVA was conducted to determine if GED rates differed for Houston ISD students before versus after the implementation of the computing programs. The test scores were statistically significantly different before versus after, $F(1, 9) = 25.940$, $p < .001$. In addition, mean scores were significantly higher before the program's implementation (*M* = 0.85%, *SD* = 0.24%) than after (*M* = 0.34%, *SD* = 0.10%).

Figure 17

GED Rate Differences 2011 to 2021 Houston

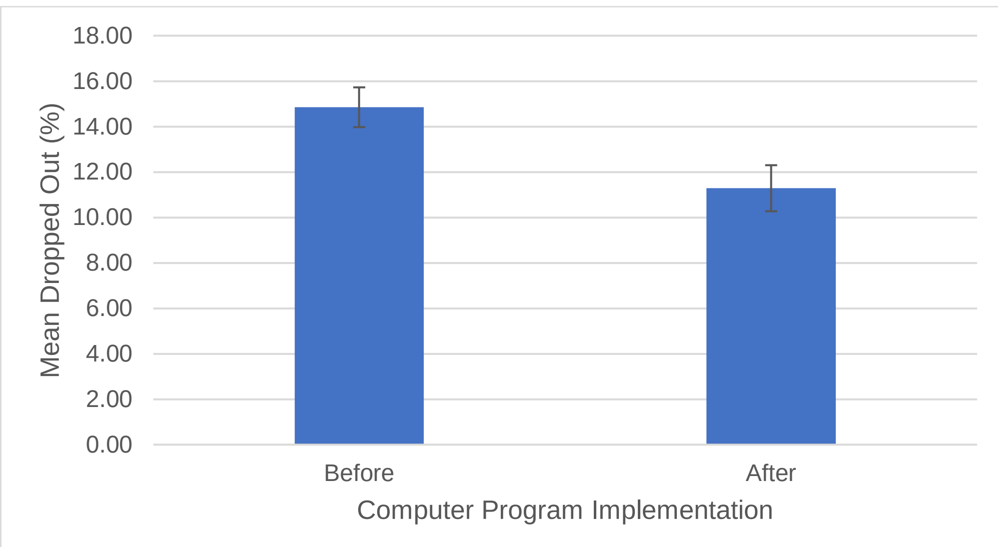


The analysis found a statistically significant difference in GED rates for Houston ISD students before and after implementing the computing programs. The significantly lower mean GED rate after the program's implementation suggests that the implementation of the computing programs reduced GED rates among Houston ISD students. This could be a positive or negative outcome based on what track students followed. This could indicate that students fully graduated from high school or it could indicated more students dropped out.

A one-way ANOVA was conducted to determine if dropout rates were different for Houston ISD students before versus after the computing program's implementation. The test scores were statistically significantly different before versus after, $F(1, 9) = 35.849$, $p < .001$. In addition, mean dropout rate scores were significantly higher before the program's implementation ($M = 14.85\%$, $SD = 0.55\%$) than after ($M = 11.29\%$, $SD = 1.10\%$).

Figure 18

Dropout Rate Differences 2011 to 2021 Houston



Results indicate a statistically significant difference in dropout rates before versus after the implementation of the computing programs. This is supported by the F-statistic of 35.849 and a p-value of less than .001. This suggests that the observed difference in continued rates between the two periods is unlikely due to random variation or chance and is more likely to be associated with the impact of the computing programs. The analysis indicated that implementing the computing programs significantly impacted dropout rates for Houston ISD students.

4.4 Total Cost of Ownership

This section presents the total cost of ownership (TCO) data for four school districts in Texas, including Fort Worth ISD, Cypress-Fairbanks ISD, Dallas ISD, and Houston ISD. The TCO data was collected for their respective 1:1 computing programs, which provided a laptop for every student. This analysis aimed to comprehensively understand the financial implications of implementing and maintaining 1:1 computing programs in high schools.

Table 1 presents the total amount spent on 1:1 computing programs for five years, 2015-2020, by four different school districts in Texas. Its purpose is to clearly demonstrate the substantial costs incurred by each district in implementing these programs by offering a comparative overview, highlighting the varying levels of expenditure undertaken by each district, thereby emphasizing the significant financial implications associated with implementing and maintaining such programs.

Table 1

Total Spent All Districts

	Fort Worth ISD	Cypress-Fairbanks	Dallas	Houston
Device	Acer Chromebook Spin 311	11.6” ThinkPad and 500E tablet	Chromebook 300E/HP 360	HP EliteBook 9470M Gen2
Total Cost – Devices	$6,841,999.71	$15,315,681.00	$20,415,990.00	$24,400,000.00
Total Cost – Infra	$2,895,734.44	$4,719,818.70	$25,900,000.00	$11,400,000.00
Total Cost – Software	$1,017,040.00	$3,800,000.00	$22,300,000.00	$16,800,000.00
Total Cost – Maintenance	$953,680.00	$750,000.00	$7,380,000.00	
Total Cost – Staff Aug	$17,000,000.00	$3,650,000.00	$15,000,000.00	
Total 5-year Spend	$28,708,454.15	$28,235,500.00	$90,995,990.00	$52,600,000.00

Table 2 details total investment made by the Fort Worth Independent School District (FWISD) in their 1:1 computing program. This three-part investment breakdown sheds light on the financial allocation across different program components, providing a comprehensive view of the district's expenditure. This data gives a broader perspective of the cost of 1:1 computing programs and their academic value in high schools. This data contributes to the ongoing discussion surrounding the correlation between financial investment in technology programs and the resulting academic outcomes.

Table 3 explains the total investment the Cypress-Fairbanks Independent School District (CFISD) made in their 1:1 computing program over five years, 2015-2020. This three-part investment breakdown sheds light on the financial allocation across different program components, providing a comprehensive view of the district's expenditure. This data gives a broader perspective of the cost of 1:1 computing programs and their academic value in high schools. This data contributes to the ongoing discussion surrounding the correlation between financial investment in technology programs and the resulting academic outcomes.

Table 4 offers an insightful breakdown of the total investment made by the Dallas Independent School District (DISD) in their 1:1 computing program over five years, 2015-2020. This three-part investment breakdown sheds light on the financial allocation across different program components, providing a comprehensive view of the district's expenditure. This data gives a broader perspective of the cost of 1:1 computing programs and their academic value in high schools. This data contributes to the ongoing discussion surrounding the correlation between financial investment in technology programs and the resulting academic outcomes.

Table 2

Fort Worth Total Cost of Ownership (Population = 22,119)

	Initial Invest and Kickoff	Investment 2	Investment 3
Device	Acer Chromebook Spin 311 @ $308.49/each		
Device Specs	11.6”, 4GB AMD A4, 32GB RAM		
Insurance	ABSOLUTE for Chrome		
Case/Accessories	13” Case		
Faculty/Student Support	Coordinator; Technology Liaison – stipend 900/year		
SAN/ERP	$147943.44		
Hardware	$152982.16	NetSync Tech Stack Upgrades $377,571.74 :: Network broadband services 1.4M	
Software	It’s Learning - $106334.00 5yrPCon :: TipWeb Asset Management platform 202,030.00		Canvas Platform @ $56,668.00/year
Infrastructure	$96798.5	Hotspot upgrade program – 1:1 home access for students @$20/line/year :: CDWG infra upgrade 96,798.50	CDW upgrade: 1.9M
Maintenance	ADP warranty program (including cases above) 2620 licenses @ $190736.00/year		
Staff Augmentation	Team Lead $56k/year		
Strategic Consulting	E-Rate cost recovery consultant @ $60k/yr		

Table 3

Cypress-Fairbanks TCO (Population = ~35,853)

	Initial Invest and Kickoff	Investment 2	Investment 3
Device	11.6" ThinkPad and 500E tablet @ $425/ea		
Device Specs	Not reported		
Insurance	Not reported		
Case/Accessories	500E Pen @ $30.00 each – no totals		
Faculty/Student Support	Not reported		
SAN/ERP	Not reported		
Hardware	Not reported		
Software	Schoology 5yr contract @ $3M :: Microsoft O365 licensing @1.3M	Power School platform $1.1M:: Microsoft 1.4M	
Infrastructure	Network updates 5year program @ $4.3M	Network Security Aruba ClearPass @ $419,818.70	Communications Infra Install @ $22M
Maintenance	NetSync laptop repair @ $150k/yr		
Staff Augmentation	Ed Tech Specialist @ $65k/year and Program Leader @ $90k/year		
Strategic Consulting	Not reported		

Table 4

Dallas TCO (Population = ~40,110)

	Initial Invest and Kickoff	Investment 2	Investment 3
Device	Chromebook 300E/HP 360 @ $509/each		
Device Specs	base		
Insurance			
Case/Accessories			
Faculty/Student Support			
SAN/ERP			
Hardware			
Software	PowerSchool/Schoology 5yr contract @ $2.9M	Iboss Filtering 1yr contract @ $1M :: Google Suite 5year license @ $14M	Carahsoft Technology/Dell software, renewals, and mint contract one year @ $4.3M
Infrastructure	Compucon 4/yr infra install project @ $18M:: NetSync wireless access install 4/yr. Install project @$2.5M	Broadband access infra upgrade CenturyLink 5year contract @ $1.8M	
Maintenance	NetSync district-wide contract 4yr @ $5.1M	ServiceNow ticketing 3year @ $380k :: ServiceNow device repair 3year @ $1.9M	
Staff Augmentation			
Strategic Consulting		Professional Services budget five years @ $15M	

Table 5

Houston TCO (Population = ~54,167)

	Initial Invest and Kickoff	Investment 2	Investment 3
Device	HP EliteBook 9470M initial choice includes tech rollout for the district, including faculty, phase 1 @ $9.8M		
Device Specs	n/a		
Insurance	n/a		
Case/Accessories	n/a		
Faculty/Student Support	n/a		
SAN/ERP	n/a		
Hardware	n/a	Phase 2 9.8M "devices"	Phase 3 spend 4.8M "devices"
Software	"platform" spend $6.7M, "filtering" spend $3.8M, "application upgrades" $2.9M, "Data Governance and UX" spend $3.4M		
Infrastructure	$11.4M 5/yr. program		
Maintenance	n/a		
Staff Augmentation	n/a		
Strategic Consulting	n/a		

Table 5 offers an insightful breakdown of the total investment made by the Houston Independent School District (FWISD) in their 1:1 computing program over five years, 2015-2020. This three-part investment breakdown sheds light on the financial allocation across different program components, providing a comprehensive view of the district's expenditure. This data gives a broader perspective of the cost of 1:1 computing programs and their academic value in high schools. This data contributes to the ongoing discussion surrounding the correlation between financial investment in technology programs and the resulting academic outcomes.

4.5 Return on Investment

Return on investment (ROI) is a financial metric that measures the profitability or effectiveness of an investment relative to its cost (Philip et al., 2012). It quantitatively assesses the returns generated from an investment concerning the initial expenditure. Understanding ROI becomes pivotal when researching the cost of 1:1 computing programs and their value in terms of academic effects. Evaluating the ROI helps determine whether the financial investment in these programs yields significant academic benefits. Examining the ROI of 1:1 computing programs plays a role in guiding educational institutions in making evidence-based decisions, ensuring that the allocated resources align with the desired academic outcomes.

The formula to determine the individual student cost of a program is:

(C / S * T)

$$\sum = \frac{(Total\ Cost) \times (\#\ of\ students\ Served)}{Duration} \qquad \text{Formula 2}$$

where C=total cost, S=students served and T=duration of program in years. Traditional ROI cannot be determined due to a lack of valuation of net revenue directly from the program itself.

Based on the traditional ROI formula, academic ROI was used to determine the returns on the 1:1 computing programs for the four districts see Table 6). Academic ROI considers the direct impact of 1:1 computing programs on educational objectives and student learning outcomes. It allows for a more accurate assessment of whether the investment is fulfilling the intended academic goals of the institution. Academic ROI extends the evaluation period and considers the long-term benefits of 1:1 computing programs, including the potential for improved educational outcomes over time. The formula for determining the academic ROI of the program is as follows:

$$\sum = \frac{(learning\ increase) \times (\#\ of\ students)}{\$\ spent} \qquad \text{Formula 3}$$

Table 6

Academic ROI for the Four Districts

District	Overall Computing Program Cost Per Student	Avg District Spend Per Student	% Spend on Computing Program Per Student
Cypress Fairbanks	$787.53	$7996.80	9%
Dallas ISD	$2268.00	$9601.00	23%
Fort Worth ISD	$1297.90	$9339.00	13%
Houston ISD	$971.00	$9170.20	10%

Academic Gains, Students, and Cost of the program were applied as the average mean score of the Algebra section of the STAAR test over a decade from 2012 to 2022.

For Cypress Fairbanks, the academic gains are a 228.25-point increase in Algebra STAAR test scores across 35,853 students with a total cost of $28,235,500, providing an average increase of 2.8 points of academic gains for each dollar spent per student enrolled in the program. No other districts' gains were associated with statistically significant changes in Algebra or English test scores during the reporting period.

High school completion metrics, including GED and dropout rates, show similar trends.

Cypress Fairbanks demonstrates upward mobility in graduation rates (2.08% gains) but a decrease in continued education rates (1.48% loss). Applying Formula 1, the academic ROI calculation for this program, resulted in 0.26% gains per dollar spent per year for graduation rate improvement and a .002% loss per dollar spent per year for re-education rate declines.

Dallas showed a statistically significant change in dropout rates, demonstrating an increase in dropouts by 2.5%, impacting ROI by .001% per dollar spent per year. Fort Worth's continued education rate dropped by 1.18% for the reporting period resulting in a .001% loss in ROI. Fort Worth lacked any other statistically significant changes during the reporting period. Houston showed a 4.76% increase in graduation rates, a .51% decrease in GEDs, and a decrease in dropouts by 3.56%. Program ROI saw a .005% gain per dollar spent per year in graduation rates, a .001% decrease from GED attainment losses, and a .003% increase from reduced dropout rates.

4.6 Summary

Only one statistically significant testing gain was detected in the data after implementing a 1:1 computing program from the four districts reviewed for this study. It was found that seven of 16 data points related to graduation metrics showed statistical significance during the reporting period and did not observe any significant changes related to the 1:1 computing program. Despite limited statistically significant testing gains, the study results suggest that the 1:1 computing program did not yield significant changes.

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

The 1:1 computing program has become increasingly popular in K-12 schools in the United States and worldwide (Ross, 2020). However, despite their widespread use, there is still a lack of research on the cost and value of these programs. This study aimed to fill this gap by exploring the cost of 1:1 computing programs and examining the potential value that can be measured by implementing these programs. Much past research explored in this study focused on singular impacts on students and faculty versus the overall value in terms of cost (Rivera Vargas & Cobo Romaní, 2020; Sancho-Gil et al., 2020). Specifically, this research aimed to investigate whether the total cost of ownership (TCO) of 1:1 computing programs can be justified by the student testing gains and graduation rates, whether student learning outcomes show a definable correlation between positive gains and the implementation of 1:1 computing programs, and whether there is a measurable return on investment of 1:1 programs based on testing gains and graduation rates. By addressing these research questions, this study seeks to contribute to the larger conversation on 1:1 computing programs and their impact on K-12 education beyond the current bodies of work, which primarily focus on student outcomes but not cost.

This chapter presents the key findings, implications, and recommendations resulting from the analysis of data gathered in this study. The conclusions drawn from the data analysis are presented first. Next, the implications of the study's results are discussed within the context of the literature review. Finally, recommendations for further research are provided, along with suggestions on how the findings of this study can inform financial decision-making related to 1:1 computing programs while continuing to support positive student outcomes.

5.1 Discussion of Results

This study used the State of Texas Assessment of Academic Readiness exam (the STAAR test) English and Algebra scores to validate assumptions and test the hypothesis. The Texas Education Agency (TEA), in collaboration with the Texas Higher Education Coordinating Board (THECB) and Texas educators, developed the STAAR program in response to requirements set forth by the 80th and 81st Texas legislatures in 2012. STAAR is an assessment program designed to measure how students learn and can apply the knowledge and skills defined in the state-mandated curriculum standards, the Texas Essential Knowledge and Skills (TEKS) scale.

Scores from before and after the implementation of the 1:1 computing programs were used as primary data sets ranging from 2012 for Algebra to 2014 for English tests (i.e., combined English Comprehension and Writing sections). These tests were used due to the abundance of research on 1: 1 computing programs that focus on technology supporting English, writing, and mathematics outcomes (Higgins et al., 2012; Ross, 2020; Shapley et al., 2011;Silvernail et al., 2010; Warschauer et al., 2006). Previous research suggested that 1:1 laptop programs can significantly impact student achievement in mathematics and writing and may lead to higher standardized test scores (Gulek & Demirtas 2005; Lei & Zhao 2007). The research conducted here did not show an overall effect on scores based on implementing these computing programs.

Success metrics, including graduation, continuation, GED, and dropout rates, were gathered from the reporting of the TEA from 2011 to 2021. Graduation rates are typically viewed as the critical success criteria for Education Technology programs, and this study adopted that focus (Goldhaber & Ozek, 2019). Though even with these types of criteria being utilized to vet and approve programs due to the *Every Child Succeeds Act of* 2015 (Lane, 2003; Texas Center for Educational Research, 2009), this research also did not find a correlation in these rates with the implementation of 1:1 computing programs. The TCO tables used to evaluate the program costs were created from disclosed purchases from the four districts and published in the school board meeting minutes and agendas. However, due to inconsistent reporting practices by the districts, some of the financial disclosure and budget information was either missing, incomplete, or over-generalized.

Academic ROI was determined through a standard formula (Formula 1) using score data, high school completion rates, and the TCO. To address the three research questions, this study used a one-way ANOVA to determine the statistical significance in the STAAR test scores for Algebra and English and high school completion rates for the districts during the observation period.

5.1.1 Question 1

Can student learning outcomes correlate with positive gains and implementing 1:1 computing programs?

Only a few instances of change showed statistical significance when looking at the metrics used in this study to examine outcomes, i.e., standardized test scores, STAAR, and high school completion data. Previous research has not been clear on showing a consistent improvement in academic outcomes. Some past research identified positive gains in English and mathematics (Downes & Bishop, 2015; Shapley et al., 2011; Suhr et al., 2010; Weston & Bain, 2010); however, others found no statistically significant increases (Hur & Oh, 2012) and others noted a decline in scores once the technology novelty wears off (Selwyn et al., 2017; Tsay et al., 2018). The findings from this study indicated no clear link between the addition of 1:1 computing programs and student success on metrics of value to the state. The costs for these programs are high; previous reports have clarified that finding and sustaining them can be a burden (Blikstad-Balas & Davies, 2017; Stover, 1999; Topper & Lancaster, 2013). There were marginal improvements in student outcomes, with small gains of less than 2% in some areas. However, only circumstantial evidence remains that digital devices are the catalysts for the change. Some studies have only reviewed a program for a single year (Muir et al., 2004; Gritter & Silvernail, 2007; Lemke & Martin, 2003), while others only look at specific subjects (Downes & Bishop, 2015; Shapley et al., 2011; Suhr et al., 2010; Weston & Bain, 2010). This research and previous research found other factors in student success, not just 1:1 computing programs (Ross, 2020).

5.1.2 Question 2

Can the student testing gains and graduation rates justify the TCO of a 1:1 computing program?

When applying a basic academic ROI formula to the statistically significant changes in student testing gains and graduation rates, there is a small rate change or learning increase per dollar spent. The TCO of a 1:1 computing program is a significant portion of the district's spending, a cost of millions of dollars, and the data was incomplete; many districts, programs, and initiatives represent substantial unreported direct and indirect spending. According to previous research, a device's total cost of ownership is five to ten times the general hardware initial cost estimate (Toyama, 2011). For example, based on the data, Dallas ISD spent 23% of its per-student budget on its 1:1 computing program, whereas Cypress Fairbanks ISD is spending an equivalent of 9% of its per-student spend on a similar deployment program. It is essential to see that the amount of district spending on 1:1 computing programs does not seem to statistically significantly affect the academic success and graduation rate metrics. The significant difference in spending between these two districts comes from costs separate from the individual devices. Dallas ISD is spending approximately six times the cost of software and infrastructure compared to Cypress-Fairbanks ISD. However, Cypress-Fairbanks ISD had large, consistent gains in academic outcomes with much lower expenditures, likely indicating a confounding factor such as a stronger curriculum, lower teacher turnover, better training, or some other component in the district that could impact student performance more than the technology.

Lack of transparency causes an issue in assessing program effectiveness or ROI. For example, Houston did not provide clear data on their spending regarding technology through publicly available avenues. The only transparent financial spending was based on the district's published technology plan and budget proposal, and districts rounded their spending assumptions irregularly, if at all. This lack of accountability with spending resulted in a skewed view of program effectiveness, ROI, and fiscal management across the district, resulting in an inability to determine an accurate TCO.

5.1.3 Question 3

Is there a measurable return on investment of 1:1 computing programs based on testing gains and graduation rates?

Based on the data reviewed during the observation period, there is a slight positive ROI trend. However, when analyzing academic ROI returns against STAAR test scores and high school completion metrics, we see fractional improvements across targets but no definitive correlation between the 1:1 computing programs and these changes versus other changes that occurred during the same period.

Unlike Houston, Fort Worth ISD and Cypress Fairbanks had published clear and concise project plans, budgets, and spending metrics related to their individual 1:1 program deployments. This transparency made determining the ROI of these programs much easier and more reliable.

In addition to these considerations, the events surrounding the COVID-19 disruptions proved an entirely new success metric for these districts – remote learning capabilities. Even though the COVID-19 event occurred during this observation period, it is clear that the 1:1 computing programs in place substantially benefited students and districts during this disruption by supporting remote learning capabilities. It is also worth noting that the STAAR test was suspended during the 2020 academic school year.

5.2 Limitations

- *Missing or incomplete financial disclosure and budget information*: The study might have missed some financial information or budget data due to inconsistent reporting practices by the districts. This limitation might have led to incomplete or inaccurate information being included in the study, which could affect the accuracy of the study's findings.
- *Lack of transparency and accountability*: The study may have faced limitations due to the districts' lack of transparency and accountability. Without transparent and accountable reporting practices, it can be challenging to understand how funds are being used and the effectiveness of 1:1 computing programs.
- *Limited evidence of a clear link between the addition of 1:1 computing programs and student success*: The study's findings may not have established a clear link between the addition of 1:1 computing programs and student success. While the programs may have improved access to technology, the study may not have found conclusive evidence that these programs led to improved academic performance.
- *Limited to four districts in Texas*: The study's findings are limited to the four districts in Texas that were included in the analysis. This means that the findings may not be generalizable to other districts or states and may not reflect the experiences of other student populations.

- *Lack of control for wealth disparity and other demographic data across the districts*: The varying financial resources and population diversity may have impacted student learning outcomes and academic performance. As a result, it is challenging to conclusively attribute the observed effects solely to the 1:1 computing program, as other contextual factors such as wealth, race, gender, education level, and socio-economic status were not controlled in this study.

Despite the limitations mentioned earlier, the study's findings hold important implications for understanding the financial value of 1:1 computing programs and their role in student success. These limitations highlight the need for further research and exploration to overcome these challenges and provide a more comprehensive understanding of the relationship between 1:1 computing programs, academic outcomes, and cost. The implications of this study extend beyond the scope of the four districts in Texas and warrant consideration for educational policymakers, administrators, and stakeholders in other districts and states. The following section delves into the implications of the study's findings, considering the broader context of 1:1 computing programs and their potential influence on student achievement. By examining these implications, we can better inform decision-making, policy development, and resource allocation to maximize the benefits of 1:1 computing and promote positive educational outcomes.

5.3 Implications

Many important implications come from this research, mainly around the efficacy of 1:1 computing program problems; the array of individual stakeholders, readiness costs, maintenance costs, improvement programs, and customer satisfaction efforts are just a few examples of the unassumed hurdles in a technology program rollout. Given what data is mandated for reporting from districts and what is voluntarily published by them, how we typically approach analyzing that data fall short of illustrating the real impact of education technology programs beyond the academic ROI calculation.

The first notable implication of this study is the view of standardized test scores as an accurate or reliable measure of student aptitude, program success, or educator efficacy. While this topic is outside the scope of this study, it is a readily identifiable implication given the standard approach to determining academic ROI in 2023.

No district conducted student/stakeholder interviews, and there is a notable lack of satisfaction metrics, pain point identification, and lessons learned. It would benefit this and subsequent studies to focus on the user experience (viewing the student as the solution customer) and other success criteria. As the integration of technology solutions evolves in the classroom, it is clear an evolution in evaluation is necessary to fully understand the impact these programs have on the students, faculty, and districts at large from both an academic ROI perspective as well as a Quality of Life and Sustainability perspective. COVID-19 demonstrated this need, with almost all students needing to be enrolled in a remote access program within a short time, without which the academic year would have been suspended, transcending the narrow view of test scores as success criteria.

Another significant question for this study revolves around device choices and variance across districts and programs. There is little documentation around device specifications, software loads, restrictions, limits, filters, and other experience-impacting differences. It is reasonable to expect device differences, software availability, and related considerations to impact the customer experience and program efficacy.

There are also several questions remaining to be answered by the field about the total cost of ownership and how best to determine the TCO of a 1:1 computing program. Variances across districts from budgeting, actual spending, allocation, device selection, accessory inclusion, and other direct and indirect spending undermine aggregate statistical analysis. This finding highlights the need for program planning, reporting, and review standardization. This study focused on binary questions and sought binary answers, approaching the questions from a business-oriented perspective related to cost, technology, and ROI. As seen in the study's limitations and the data collected, many larger and more complex questions are to be addressed beyond the monetary value of a 1:1 computing program.

5.4 Recommendations

Standardization of education technology programs and the deployment thereof is the first step. Next, there must be a common approach to device selection, deployment, infrastructure update and upkeep, refresh cycles, information security and data privacy practices, persona engagement, and reporting. Planning and actual spending must be transparent and auditable to ensure programs are sustainable, effective, and ethically sourced. A holistic review tool that considers the business of education technology and balances that with the student persona as a customer would best identify success metrics and desired student outcomes beyond standardized test scores.

5.5 Recommendations for Future Research

As noted in this study, the COVID-19 pandemic provided a new way to calculate the value of education technology programs framed in the context of school districts responding to the pandemic-required lockdowns and related distance learning initiatives. It is difficult to deny the apparent benefit of existing 1:1 computing programs providing a smoother transition to distance learning during this unforeseen disruption. However, technology literacy programs are now an integral part of the K-12 experience, and analysis of the value of 1:1 computing programs shifts dynamically across student populations. Sometimes, a 1:1 computing program may provide the only internet-capable device in a student's home. However, the device is unused in the same class because the student has a personal tablet they prefer. These dynamics should be understood at least enough to inform a more holistic view of program ROI and student impact.

To strengthen the body of research around the financial impact of 1:1 computing programs, this study recommends more exploration into one of the following:

1. How can the ROI of 1:1 computing programs be assessed more comprehensively, considering the broader impacts and costs beyond student testing gains and graduation rates?

2. What are the long-term financial benefits and drawbacks of implementing a 1:1 computing program, and how do these compare to other educational investments?

3. How can schools ensure that the cost of 1:1 computing programs is sustainable over time, and what are the key factors contributing to long-term financial success?

4. What are the potential economic benefits of 1:1 computing programs, such as increased workforce readiness and economic competitiveness, and how can these be measured and quantified?

5. How can schools effectively communicate the financial value and impact of 1:1 computing programs to stakeholders such as parents, taxpayers, and school board members?

5.6 Conclusion

Throughout this study, it has become apparent that technology deployment programs across districts require substantially higher degrees of management and intervention to ensure consistent and reliable outcomes than are currently in place. There is little to no guidance outside of budgetary limits that districts must adhere to, and as such, each program is not necessarily tailored to the students in the program but rather to the budget model of the district. Reporting practices must also be standardized so that standard success criteria and performance metrics can be reliably analyzed across programs. These foundational actions would substantially improve the reliability of this study and subsequent studies attempting to rationalize the academic ROI of educational technology programs.

The sustainability of these programs is dependent on reliable reporting and monitoring processes. The absence of common criteria means that the “cost” of a 1:1 computing program cannot be considered ‘standard’ even across districts of similar size (see Dallas ISD spending vs. Fort Worth spending). There is also no consideration for individual schools and programs in highly diverse districts. When a low-income campus is aggregated with a high-income campus, the metrics we can review are inherently skewed away from the average.

Schools cannot communicate their technology deployment plans, refresh schedules, or budgets to regulators or public stakeholders. Moreover, without precise reporting requirements, individual fiscal accountability is absent from these programs, which are responsible for spending tens of millions of dollars in most cases. A common adage in K-12 circles is that technology is not a solution; technology is a tool. Therefore, we must evaluate laptops as the tools they are and not as a panacea to solve issues within education.

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