ANALYSIS OF A 1:1 TECHNOLOGY INITIATIVE: EXAMINING IMPLEMENTATION AT THE ELEMENTARY AND SECONDARY LEVELS

A Doctoral Capstone Project

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Dedication

This work is dedicated to my late father, who was an extraordinarily gifted problem solver and natural teacher. He was also very generous with his talents, freely sharing his knowledge with anyone that could benefit. All that knew him were better for it. I try to use all that I learned from him every day to help my family, friends, and colleagues.

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Abstract

This mixed-methods study examined the efficacy of a one-to-one (1:1) technology initiative designed to provide every student in Grades K-12 with a PC device in the Wattsburg Area School District. The study also assessed the effectiveness of the related technology professional development. The purpose of this study is to improve the 1:1 technology initiative and ensure that the significant investment of time and resources is producing meaningful results. The research questions for this study focused on the teachers' perception of the effectiveness of instruction with 1:1 technology, how often and to what extent technology is used, the strengths and weaknesses of 1:1 technology, and what professional development is needed to support technology integrated instruction. Quantitative Likert data and qualitative open-ended response data were collected via an online staff survey. The survey design incorporates key findings of the literature review such as the SAMR and TPACK frameworks for technology-integrated instruction. The Quan + qual, convergent parallel study design allows for triangulation of the quantitative and qualitative survey data. Inferential statistics were used to determine if significant differences exist between 1:1 technology use at the K-6 and K-12 levels. The primary finding of the study is that the 1:1 technology initiative has been effective overall at enhancing the learning environment, but that the related professional development was inadequate to yield more effective results. To improve the program, frequent technology professional development must be provided that is differentiated, allows for adequate collaboration time, and focuses on content specific pedagogy.

CHAPTER I

Introduction

This Doctoral Capstone Project examines the benefits and challenges in implementing a *one-to-one* (abbreviated 1:1) technology initiative at the elementary and secondary levels. This study involved 74 of 102 teachers in the Wattsburg Area School District (WASD). The results from this study will inform future professional development to support the staff and improve the integration of technology in teaching and learning. Finally, the collected data will be used to examine the financial aspects of the 1:1 technology initiative and how resource allocation can be improved.

Background

Eight years ago, the WASD embarked on an initiative to have every student in Grades K-12 assigned a Windows based computing device referred to as 1:1. The physical goal of having a device assigned to each student was achieved in 2018-2019. To support this initiative, the District created stipend paid positions for technology savvy teachers to support the rollout and use as well as providing ongoing teacher training. These teachers are referred to as *Technology Integrators*. In conducting walkthrough observations of 25 elementary classrooms utilizing the entire administrative team in 2018-2019, administrators learned that the level of device utilization varied significantly from classroom to classroom. Use of the devices ranged from well-planned integration into lessons to mostly cosmetic or superficial use. The administrative team expressed concern regarding how and how often technology is used in the classroom. Possible reasons for varying degrees of technology use and differences between the elementary and secondary level use is another area of interest that will be explored.

Capstone Focus

This is an action research project (Quan + qual, convergent parallel design) utilizing a staff survey to collect data related to the research questions and data classification. This study is mixed method, analyzing quantitative survey data using descriptive statistics and two-tailed independent samples *t*-tests to determine if survey response data reveals any significant patterns. For example, are there statistically significant differences in how teachers perceive the effectiveness of 1:1 technology between the elementary (K-6) and secondary levels (7-12)? Are there statistically significant differences in perception of 1:1 technology professional development? Qualitative data in the form of open-ended questions were also collected and analyzed via coding. Survey data were collected from participating teachers via a secure online form (Microsoft Forms).

Research Questions

1. What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment?
2. How often and to what extent is 1:1 technology integrated into instruction?
3. What are the strengths and weaknesses of technology integrated teaching and learning?
4. What professional development is needed to support technology integrated instruction?

Expected Outcomes

This research seeks to assess how and how often 1:1 technology is being integrated into instruction. The study also endeavors to assess what may be needed to enhance instructional integration. Financially, the study's results will be used to investigate if the annual expenditure of approximately $700,000 to support and maintain the 1:1 program is providing a worthy return on investment in terms of enhancing educational delivery. For example, is 1:1 technology deployment more appropriate at some grade levels or in some subjects more than others? Are the Technology Integrators providing adequate professional development and support? Or, are we spending too much on devices with overcapacity in terms of the level of integration appropriate at each grade level e.g., would less expensive Chrome Books be adequate in Grades K-6 rather than Windows based devices? The overarching goal of the study is to provide data that can be used to evaluate the current use of 1:1 computing in Grades K-12 and how it can be improved to enrich learning.

Fiscal Implications

Expenditures for the 1:1 initiative PC device initiative encompass both hard and soft costs that are directly and indirectly related. Table 1 depicts hard costs that may be adjusted considering the results of this Doctoral Capstone Project. The Pennsylvania Chart of Accounts line item codes denoting technology expenditures were used to extract this data from the District's financial management software and are included in the Account Column (Pennsylvania Department of Education, 2021a).

Table 1

Doctoral Capstone Project Budget Overview

Account	Description	Budget ($)
10.1100.650.000.00.00.000	Instructional technology supplies / software fees (programs and licenses for instructional classroom use: Pear Deck, Wit & Wisdom, Atlas, Eureka Math, Study Island, monitors, cables, projectors, Elmos, E-Hall Pass, spare student laptops)	62,860.00

Account	Description	Budget ($)
10.1100.650.000.00.00.000	Instructional technology supplies / software fees (grades 1-2 laptop purchase)	52,000.00
10.1211.650.000.00.00.000	Life skills technology supplies / software fees (online newspaper subscription, student iPad)	1,400.00
10.2220.141.000.00.00.000	Client technology specialist salary	39,305.00
10.2220.210.000.00.00.000	Client technology specialist group benefits	7,763.27
10.2220.220.000.00.00.000	Client technology specialist FICA	3,007.00
10.2220.230.000.00.00.000	Client technology specialist PSERS	13,565.00
10.2220.320.000.00.00.000	Technology professional education services	4,000.00
10.2220.348.000.00.00.000	Technology plan support services (consultants/tech support)	24,000.00
10.2220.438.000.00.00.000	Technology repair and maintenance services (technical support/services)	35,000.00
10.2220.448.000.00.00.000	Teacher laptop lease agreement (110 devices)	71,587.00
10.2220.448.000.00.00.000	High school laptop lease agreement (550 devices)	59,224.00
10.2220.448.000.00.00.000	Grades 3-8 laptop lease agreement (850 devices)	56,589.00
10.2220.448.000.00.00.000	Technology printer lease	600.00
10.2220.530.000.00.00.000	Technology postage/shipping	500.00
10.2220.538.000.00.00.000	Technology internet services (Zito Media)	31,000.00
10.2220.538.000.00.00.000	Technology cellular services	3,400.00
10.2220.580.000.00.00.000	Technology travel (mileage, meals, lodging)	1,500.00
10.2220.610.000.00.00.000	Technology supplies (general office, shipping supplies, etc.)	5,000.00
10.2220.650.000.00.00.000	Microsoft Office annual agreement (Office 365)	25,481.00
10.2220.650.000.00.00.000	Technology related supplies / software fees (cameras, av materials, software subscription renewals, cables)	195,000.00

Account	Description	Budget ($)
10.2220.810.000.00.00.000	Technology prof membership dues/fees	500.00
10.3210.191.000.00.00.000	Tech integrator stipends (6 positions)	17,298.00
10.3210.220.000.00.00.000	Tech integrator stipends FICA	1,324.00
10.3210.230.000.00.00.000	Tech integrator stipends PSERS	5,970.00
	Total	717,873.27

Budget Narrative

The line item for technology supplies and software fees in the amount of $62,860 is directly related to supporting the 1:1 initiative and has greatly increased by the addition of approximately 1,600 individual staff and student devices over a five-year period. Grade 1-2 technology equipment and fees total $52,000 as these are the only devices in the 1:1 initiative that are not on a lease cycle. There are two primary reasons for this. One, the devices are surface tablets as opposed to the laptops in Grades 3-12, which the teachers feel a more appropriate for the youngest students. Two, these devices were relatively inexpensive and there was no advantage when a lease cost was examined.

There are a total of 1,400 Windows 10 devices deployed in Grades 3-12 that are on a three-year rotating lease agreement costing $115,813 annually. In addition, 110 high-end Surface Laptops are assigned to faculty on a three-year rotating lease at a cost of $71,587. Lease agreements are staggered with the devices coming due for replacement in approximately thirds. In other words, there are no machines in the District older than three years at any given time. This also means there are always a third of the machines that are two years old, and a third that are one year old, which greatly reduces the need for time consuming technology department support.

The other non-personnel related significant costs that are directly related to supporting the 1:1 initiative involve the line item for maintenance and repair at $35,000, $31,000 for hi-speed Internet access, and $25,481 for Windows 365 subscriptions. The latter has proven to be very cost effective as it provides every student and staff member one terabyte of cloud storage and up to five Office 365 application installations. The direct result has been a reduction in one-off application licenses and the need to maintain large servers for local data storage.

Personnel Costs

Technology related personnel costs are significant and have evolved as the District has deployed and implemented an increasing amount of technology for teaching and learning. However, the project budget does not reflect all the personnel costs related to the District technology operations as a minimum amount of technology staff is required to administer the system regardless of the number of devices. For example, a technology administrator is needed to oversee and coordinate all technology systems in the District, coordinate e-rate purchases, organize trainings, and manage the technology budget. Additional staff both in-house and subcontracted are required to maintain databases, repair, and install equipment, and manage the network which again, is needed irrespective of the number of individual devices deployed.

The line items in the project budget for the Client Technology Specialist salary and benefits is directly related to the 1:1 initiative and totals $63,640. As more devices were put into the service, there was a natural increase in the need for a consistently manned helpdesk to handle day to day individual machine issues. As a result, a full-time in-house client specialist was hired. The other direct personnel cost need that emerged is providing regular support to teachers in how to integrate technology into teaching and learning. We initially hired one full-time person to function in this role but found one person spread among three school buildings was ineffective. At the suggestion of some of the more technology savvy teachers and a review of research by the curriculum director, six teachers were recruited, received advanced technology professional development, and are paid an annual *Technology Integrator* stipend to provide training and support to their colleagues before and after school at a total salary and benefit cost of $24,592. The survey instrument for this research project will collect data to assess the effectiveness of the Technology Integrator approach to providing staff support.

Indirect Costs

The largest hard indirect cost is the $195,000 line item for technology related supplies and equipment. The nature of these expenses changes every year due to the ever-changing needs related to the deployment of such a large amount of technology throughout the District. For example, these funds might be used for a variety of purchases such as classroom LED projectors, replacing and updating servers, network connectivity (switches), portable device charger replacements, back up batteries for the servers, etc. We have found that it is necessary to have a dedicated line item for these types of needs so we can proactively plan replacements to avoid downtime for reactive repairs, which negatively impact the entire organization.

An indirect cost that is difficult to measure is increased staff time dedicated to managing a large volume of technology. There are increased time impacts at all levels of the organization ranging from the time it takes the technology department to reimage 1,600 laptops each summer to the increased preparation time required of teachers to successfully integrate technology use into teaching and learning. The questions in the project survey instrument are designed to capture quantitative and qualitative data regarding staff time expenditures related to the 1:1 initiative.

Summary

The total estimated annual hard costs related to the 1:1 initiative total $717,873.27. This represents a considerable investment within the District's approximately $25 million general fund budget. As such, it is important that the initiative is effective in terms of return on investment financially and educationally. This research project will help to assess the overall efficacy of the program allowing expenditures to be redirected towards the most effective purchases and professional practices to maximize student learning. This may not mean simply reducing cost but rather, ensuring the District is getting the best possible results for justified expenditures that truly enhance teaching and learning through effective integration of technology.

CHAPTER II

Review of Literature

Technology has long been a part of education. Perhaps the earliest technology used in education were the materials and implements used by students and teachers to write. Ancient Egypt yields a wealth of archaeological evidence of early writing technology using a variety of materials such as bone styli, clay tablets, papyrus, reed pens, and wooden writing boards to write text and express meaning using non-textual marking systems (Pinarello, 2018). Also, the extensive practice in Ancient Egypt of engraving stone monuments and painting tomb interiors with Hieroglyphics has been comprehensively studied to reveal the origins of their phonetic alphabet as well as word and syllabic signs (Rollo, 2021) that represent a type of ancient shorthand. Handwriting technology did not evolve significantly for centuries. According to Bates (2015), the use of slate boards occurred in 12th century AD, and chalkboards moved into schools in the 18th century.

The invention of the printing press in Europe in the 15th century was a disruptive technology advancement in written knowledge (Bates, 2015) leading to a dramatic increase of documents and recorded knowledge that could be readily shared. According to Bates (2015), this led to the need for more people to become literate as the world's economy adapted and evolved in response to this printing innovation. The development of the postal system in the 1840s facilitated correspondence education, perhaps the most notable development in educational technology in the 19th century. Although the focus of this literature review is on the use of computers in education and the classroom, it is worth listing several key technology developments in the 20th century that impacted education leading up to the introduction of computer technology in schools:

- Electricity become more widely available in the 1920s which ushered in the age of radio, which could be used as a new instructional medium (Hof, 2018).
- Radio was followed by the development of film and television technology during the first third on the 20th century leading to many audio-visual educational opportunities (Petrina, 2002).
- Early work in the development of automated teaching devices occurred in 1925 with the invention of Sidney Pressey's intelligence-testing machine (Petrina, 2004).
- Overhead projectors were introduced by the U.S. Army after World War Two for training, which were widely adopted for lecturing in education (Bates, 2015).
- In 1951, the first modern slow speed video tape was invented by a team of engineers at Ampex Corporation lead by Charles Ginsburg (Hammar, 1994).
- B.F. Skinner's teaching machine was developed in 1954 and built upon the immediate student feedback design of Pressey's intelligence-testing machine (Day, 2016).
- The launch of the Sputnik satellite by the Soviet Union in 1957 and resulting Cold War initiated a significant period of technological development in the United States to increase efficient learning (Hof, 2018). These efforts ultimately resulted in the development of digital technology and the proliferation of computing devices.

- The 914 model copier machine was introduced in 1959 fundamentally changing how documents could be produced and knowledge shared (Jacobson, 1989).
- Electronic calculators were introduced in 1971. By the mid-1970s, the cost of calculators dropped to about $20 making them affordable, which led to a proliferation of the devices entering classrooms (Schafer et al., 1975).

History of Computers in Schools

When did computers first start to appear in American schools? Although the first computers in our schools can be traced back to early military models and federally supported technology initiatives in schools during the 1950s (Coley et al., 1997), the first organized application of computers in schools began in the 1960s. The focus at this time was on Computer-Assisted Instruction (CAI), which is using computers for drill and practice (Lidtke & Moursund, 1993). Another early approach featured teaching students how to write programs in BASIC, an early programming language (Beavers et al., 1969 as cited in Lidtke & Moursund, 1993).

Widespread use of computers in schools did not occur until the early 1980s with the introduction of self-contained desktop or microcomputers that were as powerful as their much larger predecessors in previous decades. Dramatic reductions in cost also fueled this trend. Between 1978 and 1984, the price of computers at a specified performance level declined by 50 percent (Levin, 1985). Between 1981 and 1983, the percentage of K-12 schools in the United States with computers grew to well over 50 percent (Becker, 1984). A national survey at the time revealed 53 percent of elementary schools and 85 percent of high schools having at least one computer (Levin, 1985). The predominant computer hardware in K-12 education at this time was Apple (Sumansky, 1985). This was due, in part, to Apple Computer's nationwide initiative in the mid-1980s to develop and research innovative uses of computers in K-12 education called Apple Classrooms of Tomorrow, abbreviated ACOT (Ross, 2020).

Early Computer Use in Schools

As computers became more prevalent in schools in the 1980s, several camps emerged regarding how they should be used. Disagreement occurred between advocates of computer aided instruction, teaching computer programming, and teaching computer applications (Lidtke & Moursund, 1993). As a result, the rationale for having computers in school was not clear and the increased purchases of computers often resulted in only marginal use with wide variations in application by administrators, teachers, and students (Parker & Davey, 2014). Another obstacle in using computers in schools that persisted up through 1990s was the deployment method. Schools invested heavily in shared computer labs where teachers could have their students use the machines during specified periods of time each week (Becker, 2000). This model proved to be less than effective as it involved time consuming coordination and frequent disruptions in classroom routines and locations.

Computer Aided Instruction (CAI)

The development of CAI can be traced back to the early learning machines of Pressey and B.F. Skinner in the 1920s (Silverman, 1961) but did not begin in earnest until the 1960s and gradually developed over the subsequent two decades. A primary goal of computer use in education that emerged in the 1980s was to utilize it as a personal tutor that makes education interactive with individualized content and immediate feedback (Lepper & Gurtner, 1989). A secondary goal that developed at this time in CAI was to use the computer for exploratory learning to complement and reinforce traditional curriculum content.

In the mid 1980's, CAI software to teach reading rapidly expanded into schools. In response to concern over the quality and effectiveness of such software, the International Reading Committee released guidelines to assist in selecting effective software (International Reading Association, 1984). The report contained 16 software selection recommendations primarily focused on learning such as:

- clearly stated and implemented instructional objectives.
- learning to read and reading to learn activities which are consistent with established reading theory and practice.
- lesson activities which are most effectively and efficiently done through the application of computer technology and are not merely replications of activities which could be better done with traditional means.
- wherever appropriate, a learning pace which is modified by the actions of the learner, or which can be adjusted by the teacher based on diagnosed needs. (p. 120)

The early evaluation efforts of CAI effectiveness in terms of student achievement showed it to be no more effective than traditional methods (Siegfried & Fels, 1979). Schenk and Silvia (1984) criticize this early research because it did not take into account possible variables in evaluating CAI besides the technology itself such as poor material, improper computer use, or attempts to achieve goals that are difficult even when using traditional methods such as lecture and discussion. Criticism of CAI was not limited to just achievement concerns. Skeptics worried that computerization of teaching and learning could lead to increased drills and homogenization of the learning process, which could hinder students not suited to this type of instruction (Lepper & Gurtner, 1989). Becker (1984) summed up the reality of CAI in the mid-1980s:

> This drill-and-practice application differs substantially from the infinitely patient and directly instructive tutor imagined in our dreams about computer-assisted instruction (CAI). Most existing drill-and-practice computer programs do include some elements of good instruction for example, moving students rapidly through many short problems ordered according to difficulty, providing immediate reinforcement (cognitive and affective feedback regarding performance), and using information about the student's prior performance to guide subsequent testing and practice. (p. 29)

The development of more sophisticated CAI accelerated as computers became more powerful through the 1980s. In the early 1990’s computer applications and CAI became the dominant K-12 educational technology. CAI software often consisted of comprehensive courseware packages featuring support materials as well as integrated learning systems that covered large parts of the curriculum at multiple grade levels (Lidtke & Moursund, 1993). Many of these CAI models were constrained by the amount of customized programming they required to produce and computer memory limitations. The growth of the Internet at the end of the 1990’s enabled CAI to be fully realized as a powerful learning tool. With regards to the impact of the Internet on CIA, Daniels (1999) writes:

> Web browsers provide an inexpensive and widely available application that can combine text, graphics, audio, video, data, and programming within the same

software program. The student can use a familiar interface to access these forms of information without having to master different applications. (p. 166)

Computer Programming

In the 1980's, proponents of teaching computer programming contended that teaching programming languages in high school could promote higher level thinking skills like problem solving (Lin & Dalbey, 1985 as cited in Palumbo & Reed, 1991). Research was also conducted during this time finding positive linkages between problem solving in mathematics and computer programming (McCoy, 1990 as cited in Bennett, 1991). The dominant programming language during this period was BASIC as it was built into the Read Only Memory (ROM) of many computers, which made it possible for schools to offer computer programming on a larger scale (Lidtke & Moursund, 1993).

Studies into the benefits of teaching computer programming like BASIC focused on how it could promote transfer of learning. Salomon and Perkins (1987) proposed that transfer of learning occurs from programming in two distinct ways they called *low road* and *high road transfer*. Low road and high road transfer were referred to as *near* and *distance transfer* in subsequent research by others. Near transfer refers to when a learned skill can be readily transferred to a new similar problem set (Burton & Magliaro, 1988). An example of near transfer born out in research showed that students who became proficient in a programming language could more easily learn another programming language (Dabley & Linn, 1986 as cited in Palumbo & Reed, 1991).

Distance transfer is when a learned skill such as programming can be transferred to a dissimilar problem set. Linn (1985) explains that this transfer of problem-solving ability is due, in part, to the computer learning environment itself. That is, computer programming requires programmers to break down complex problems into subproblems which require very specific stepwise instructions. It is this algorithmic thought process required to create successful programs that lends itself to the transfer of problem-solving skills to other domains.

BASIC came to be viewed as the least beneficial in terms of teaching problem solving skills because of its general lack of structure as a programming language (Palumbo & Reed, 1991). Logo, originally developed in the late 1960s, emerged as an alternative to BASIC in the mid-1980s (Clements, 1999). Logo became popular because it appeared very well suited to transfer of learning in six key areas (Salomon & Perkins, 1985 as cited in Keller, 1990):

> (a) mathematical and geometric concepts and principles; (b) problem solving, problem finding, and problem management strategies; (c) abilities of formal reasoning and representations; (d) models of knowledge, thinking, and learning; (e) cognitive styles, such as precision and reflectivity; and (f) enthusiasms and tolerance for meaningful academic engagement. (p. 55)

A key component of Logo's potential to promote transfer of learning is its unique graphic interface (turtle). The turtle is often represented on the screen as a small triangle. It is moved by entering simple commands (Logo Primitives) on a prompt line such as BACK, FORWAD, LEFT, and RIGHT. As the commands are entered, the student receives instant feedback in terms of how the turtle reacts to each command. Hamner and Hawley (1988) note that the procedural nature of the process and the fact that multiple small commands or procedures can be combined into a more complex procedures promotes a scientific problem-solving mindset. Despite educator enthusiasm for Logo, critics in the late 1980's pointed to a lack of conclusive research substantiating Logo's effectiveness in enhancing problem-solving skills (Bracey, 1988 as cited in Hamner & Hawley, 1988)

Computer Applications

A third area of computer use in schools during the developmental 1980s and 1990s was the proliferation of computer applications. The use of computer applications differs from CAI in that the applications are used as a tool in the educational process or area being studied. For example, just as calculators became an integral part of high school business education classes, word processing and bookkeeping applications were also adopted as a necessary part of the curriculum (Hofmeister, 1982). The use of applications in schools also expanded to include administrators adopting word processing, database, and spreadsheet applications for information management tasks such as student attendance, scheduling, and school budgeting (Benson et al., 1999).

In the early 1990's, the focus began to shift from simply learning to use computer applications in a particular way to how educators could best apply or use computers from a pedagogical standpoint. For example, Wepner (1990) explores the integrated use of computer applications to teach reading and writing throughout a series of literature based lessons in several elementary schools. Wepner (1990) sums up her observations of integrated computer use in teaching stating, "the computer is not an embellished drill sheet that is tacked onto a lesson; rather, the software embodies the goals of instruction" (p. 15). Near the end of the 1990's, the growing focus on technology and pedagogy was expressed in several key recommendations from a presidential report on the use of technology in K-12 education (Shaw et al., 1998):

- Focus on learning with technology, not about technology.
- Emphasize content and pedagogy, and not just hardware.
- Give special attention to professional development.

These recommendations are topics that are explored in-depth later in this review of literature as teaching pedagogy has expanded substantially in the past twenty years to encompass the significant role computers now play in classrooms. Also, this study examines how teachers utilize computers in their classrooms through the lens of two current conceptualizations of technology integrated instruction:

- *Substitution, Augmentation, Modification, and Redefinition* (SAMR)
- *Technological Pedagogical Content Knowledge* (TPACK).

Computer purchases and usage in K-12 schools continued to rise significantly through the 1990s. This growth set the stage for Internet use in K-12 schools. According to Zeller (1999):

> In just six years, the number of computers in public schools has more than doubled, to 7.4 million in 1998. Spending on instructional technology from kindergarten through grade 12 rose sharply as well, to more than $5 billion last year [1999] from $2.1 billion in 1992. (p. B9)

Transformational Technology

Origins of the Internet can be traced back to 1969 when the Department of Defense created the Advanced Research Projects NETwork (ARPANET) so the military could collaborate with researchers (Swain et al., 1996). However, it was not until the end of the 20th century that a dramatic expansion of telecommunications around world coupled with ever more powerful computer technology resulted in the widespread proliferation of the Internet (Robison & Crenshaw, 2002). By 2001, the United States was the leader in Internet deployment and use with the United Kingdom, Canada, Germany, and Japan close behind (Cheung, 2001 as cited in Deboo et al., 2002). The exponential growth of the Internet through the early 2000s was a disruptive technology advancement that had an unprecedented transformative impact, forcing a reorganization of work and the economy (Chapman et al., 2000). Computers and the Internet also spread into K-12 schools at this time at an even faster rate than the rest of society (Chapman et al., 2000).

Internet in Schools

In the early 2000s as computers and Internet or Web access became widespread in K-12 schools, broad consensus formed that it would play a pivotal role in education and bring about fundamental improvements in teaching and learning (Maddux, 2004). Despite this, Internet use by K-12 students at the time lacked a clear consensus on how it could best be applied beyond simply accessing information contained on web pages. This was like the earlier computer use dilemma of the 1980s. Chapman et al. (2000) states that a primary reason for this was a widespread concern at the time that K-12 schools were not performing well and needed to be reformed. This, in turn, made technology and the Internet a controversial and complex part of school reform efforts (Chapman et al., 2000). There were also many questions posed by educators and administrators regarding the role the Web can or should play in education such as making learning more accessible, promoting improved leaning, and helping to contain costs (Owston, 1997). With the introduction of *Web 2.0* technology, many of the initial concerns around use of the internet in education began to abate as the advancements associated with Web 2.0 applications made the internet much more interactive and its potential to enhance education apparent.

Web 2.0

Web 2.0 applications and tools began to trend in usage around 2004. These applications were characterized by their capacity to enable users to interact via the Internet in a very open and transient manner (Barsky, 2006). Wikis, weblogs, podcasts, steaming media, and sites like YouTube started to become widely available at little or no cost and were easily learned by teachers and K-12 students (Norton & Hathaway, 2008). A key feature of Web 2.0 applications is the user's ability to generate and post their own content to the web directly with a user-friendly interface rather than writing HTML code. This new self-publishing functionality was not without its issues though. As user-generated content began to populate the Internet, determining the quality or actual source became problematic (Liu & Maddux, 2008).

As with other technology innovations, Web 2.0 was disruptive as it rendered many applications and software that were installed on individual computers obsolete or burdensome (O'Reilly, 2005 as cited in Cash et al., 2010). An example of this would be the development of Google Docs, an open source and web-based word processor (Cash et al., 2010). Before Google Docs, word processing applications such as Apple Pages, ClarisWorks, Word Perfect, and Microsoft Word were purchased and licensed to individual computers. The appearance of free Web 2.0 open-source applications led to a significant increase in K-12 educational use of the internet and technology on a routine basis in the 2000s. A National School Boards Association study (2007) revealed that 96% of leaders from 250 school districts reported that some of their teachers assign homework that required Internet use. A third of the district leaders in the study reported that more than half of their teachers assign homework that required Internet use. The overall impact of Web 2.0 was a significant shift away from individual computer applications and viewing static webpages in K-12 education towards interactive information and communication technology. Web 2.0 technology also significantly enhanced Computer Aided Instruction as it allowed a migration of these learning systems to the internet or to what we now refer to as the cloud or cloud computing.

Information and Communication Technology (ICT)

ICT covers a broad range of technology. Rouse (2005) as cited in Saqib et al., (2015) defines ICT as an inclusive term:

> that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning. (p. 85)

In the 2010s, the integration of ICT into all aspects of life also began to impact education. Dryer (2010) writes, “By March of 2010, there were 200 million blogs worldwide, 450 million people on Facebook, 27 million tweets every 24 hours, and 1.2 billion YouTube views each day” (p. 16). As a result of this increased connectivity and communication, educators were encouraged to tap into the social nature of Web 2.0 to optimize learning (Hung & Yuen, 2010 as cited in Holmes et al., 2014). Like other technology innovations in education, the adoption and use of ICT was not without its critics.

Early research into the effect of ICT on student achievement found that students gained proficiency in using ICT but that it did not necessarily transfer its application to other subjects (Harrison et al., 2003 as cited in Livingstone, 2012). Subsequent studies showed positive impacts on student achievement appeared in some subjects more than others. For example, in primary schools, English was found to be positively impacted, moderately in science, and not at all in Mathematics (Balanskat et al., 2006 as cited in Livingstone, 2012). Studies that focused only on the use of ICT in reading instruction showed it to be an effective multimodal tool. In a study by McDermott and Gormely (2016), they observe:

> Digital white boards were often used for multimedia displays of lesson content in both the primary and intermediate grades. The primary-grade teachers used their digital white boards to display text, videos, graphic arts, and websites as well as to access to audio (voice and music) relating to the reading lessons. (p. 131)

The work of McDermott and Gormely (2016) revealed that ICT primary-grade reading instruction is often very social in nature and involved shared writing, passing the digital whiteboard pen, and choral reading. They also observed a perhaps hard to quantify benefit in that technology contributed to an efficient flow of learning activities and very few behavioral disruptions during observed lessons.

Blended learning is another way that ICT can be used to efficiently organize the learning environment by combining traditional classroom practice with technology-based learning (Saqib Khan et al., 2015). An example might be students assigned a traditional activity like reading silently and then moving to an ICT application that assesses their comprehension of what they just read. The advantage of this is that they get instant individualized feedback from the technology, which can be further enhanced by an online chat with the teacher (Saqib Khan et al., 2015). Blended learning is just one of the many positive benefits of ICT that is noted in the research. Fu (2013) outlines many such benefits in her thorough review of ICT research such as:

- Assist students in accessing digital information efficiently and effectively
- Support student-centered and self-directed learning
- Produce a creative learning environment
- Promote collaborative learning
- Offer more opportunities to develop critical thinking skills
- Improve teaching and learning quality. (p. 113)

Ethical Considerations

Students and teachers are becoming connected to each other and the world more than ever before which requires careful ethical consideration. For example, technology as a distraction, preparation of students for workplace use, and prevention of problems with misuse and addiction are all important issues when integrating technology into the educational environment (Willard, 2000). The pace of development of educational technology is currently very fast and is also accelerating. This calls for a close examination of efficacy as it relates to taxpayer investment and educational effectiveness of the growing range of EdTech products (Regan & Jesse, 2019). Edtech companies see vast potential for profits in K-12 education making it ever more important to ensure that the claims of the efficiency and effectiveness of their products are legitimate. Especially in light of the fact the target population of Edtech products involves minors that can have a significant amount of needs and developmental issues during their K-12 years (Regan & Jesse, 2019).

The gathering of student information by Edtech is another area of concern. In 2000, a common marketing model of many technology companies was to offer free equipment or service trials in exchange for the opportunity to collect data regarding student and staff use of the Internet (Willard, 2000). Willard continues stating that "Information about student use can then be used to guide marketing programs for companies selling products to young people or to individually target students with information about products that might match their personal interests" (p. 237). As of the publication of her article on March 2, 2000, Willard noted that researchers are bound by strict rules regarding the collection of student data and required parental consent but that commercial research has no such constraints, although congressional restrictions were being considered at the time.

A third area of ethical concern related to the collection of data by Edtech is student privacy. These concerns deal with issues such as the security of student data in databases and ownership of student data by third party data collectors or student learning applications. In 2015, eight education data privacy bills were introduced in congress focusing on various student data issue but none of them moved beyond committee consideration (Regan & Jesse, 2019). "On May 17, 2018 the US House Education and Workforce Committee held a hearing on the topic of protecting privacy, promoting data security: exploring how schools and states keep data safe" (Regan & Jesse, 2019, p. 173). Like the 2015 congressional discussions regarding education data privacy, this Workforce Committee hearing did not result in any Federal action. On July 29, 2021, the House discussed a proposed bill to prohibit surveillance advertising using student data, to require education technology audits, and for other purposes but did not act on it (Bradley, 2021). It appears that despite much discussion and proposals, not much federal progress has occurred regarding the regulation of commercial collection and use of student data in the past 20 years. However, states have made considerable progress in addressing these issues. “Between 2013 and 2017, 49 states have introduced 503 bills, and 41 states have passed 94 new laws expressly addressing the privacy and security of education data” (DQC, 2017 as cited in Regan & Jesse, 2019, p. 173).

Summary – History of Computers in Schools

The first section of this literature review provided a recap of early technology use in education focusing on key developments in the 20th century that eventually brought about the significant use of computers in education. Widespread early use of computers in schools began in the 1980s. Computer use at this time was not particularly focused and was generally divided into three primary uses: computer aided instruction, teaching of computer programming, and use of computer applications such as word processors and spreadsheets. Near the end of the 20th century, a dramatic expansion of telecommunications coupled with ever more powerful computer technology resulted in the widespread proliferation of the Internet and other transformational technologies in K-12 schools.

Internet use in schools was simple at first and consisted primarily of teachers and students visiting static webpages. The advent of Web 2.0 applications in the mid-2000s made the Internet a much more interactive medium allowing users to interact with information and communication applications such as social media. Web 2.0 also allowed users to easily post their own content to the internet in formats like blogs and wikis. This expanded interconnectivity raised ethical concerns regarding student data collection, student privacy, and data ownership. The next major advancement of technology use in K-12 education came about as the cost of technology and internet connectivity continued to drop into the 2010s resulting in computers moving out of traditional static computer labs and into classrooms in the form of laptops, tablets, and digital smartboards.

1:1 Student Technology

The declining cost of technology and rapid spread of internet access fueled a trend to place computers directly into classrooms during the 2000s as a means to improve student achievement (eSchool News, 2006 as cited in Holcomb, 2009). Despite large infusions of computers into schools and reduced student-computer ratios, widespread classroom use was often inconsistent. Obstacles such as the scheduling of shared computer labs or mobile carts discouraged teachers from routine use (Cuban, 2003; Warschauer et al., 2004 as cited in Grimes & Warschauer, 2008). Advocates of more consistent computer access and use responded by promoting one-to-one computer programs that enabled all students to have access to a laptop throughout the duration of the school day (Grimes & Warschauer, 2008). The initial goal of one-to-one computing programs (abbreviated 1:1) was to ensure students had ready access to an Internet connected computing device such as a laptop or tablet directly in classrooms as opposed to going to traditional static computer labs. As the initiatives progressed, many schools assigned each student a networked capable dedicated device that could be transported to and from home. Home use of microcomputing devices was limited by individual community internet access. This is still a significant obstacle today to fully realizing the benefits of 1:1 computing programs, especially in rural school districts where building out internet infrastructure is fiscally prohibitive.

1:1 Computing Program Definition

For the purposes of this review and Doctoral Capstone Project, the definition of a 1:1 computing program is one that features three common characteristics identified by Penuel (2006):

> (1) providing students with use of portable computing devices loaded with contemporary software (e.g., word processing tools, spreadsheet tools, etc.), (2) enabling students to access the Internet through wireless networks in school (and home when possible), and (3) a focus on using portable computing devices to help learning activities such as homework assignments, tests, and presentations. (p. 331)

Early 1:1 Computing Programs

Early studies of 1:1 computing programs in schools reported that "they increase students' engagement in school, improve technology skills, and have positive effects on students' writing" (Zucker & Light, 2009, p. 82). However, research in the early 2000s on the effectiveness of 1:1 programs was preliminary and limited. As a result, many questioned the effectiveness of 1:1 programs due to the lack of empirical evidence on their effectiveness (Lei & Zhao, 2008). Also, the considerable cost of implementing 1:1 programs added to the need for evidence of their benefits to teaching and learning (Grimes & Warschauer, 2008).

A research synthesis of early 1:1 computing programs summarized by Penuel (2006) focused on initiatives in K-12 education that used laptop computers with wireless connectivity. In addition to providing increased student technology access, the research synthesis revealed that the goals for the programs focused around one to four outcomes:

improving academic achievement, increasing equity of access, increasing economic competitiveness by preparing students for a technology driven workplace, and transforming instruction by focusing on differentiation and the use of higher order thinking skills. The most commonly observed use of the laptops involved teachers adapting traditional teaching strategies to include the use of technology by the students working independently and in groups (Penuel, 2006). The research synthesis found only four groups of researchers utilized a pretest-posttest design with control groups. The results of these studies showed a positive effect in the areas of computer literacy and writing similar to findings of a previous review (Penuel et al., 2001 as cited in Penuel, 2006).

Other studies at this time focused on how a 1:1 laptop program impacts the school environment. For example, how are the laptops used by students and what are the effects? What are the perceptions and concerns with 1:1 computing? Research by Lei and Zhao (2008) found that students most commonly used laptops for taking notes, searching information on the Internet, learning subject content with specific software, and learning through online discussions. Their study suggested that "having one-to-one computers can significantly help increase student technology proficiency because of the increased opportunities of learning technology knowledge and skills while using the laptops to work on various tasks for learning, communication, expression, and exploration" (p. 117). They also found that teachers and students believed that laptops enhanced the learning experience. Finally, the most common concern from teachers and parents regarding 1:1 computing was perceived uncertainty, which is common in the early stages of implementation (Lei & Zhao, 2008).

Effect of 1:1 Computing on Student Achievement

With the continued growth of 1:1 computing programs, research has focused on the effect they have on student achievement. A collective review of 1:1 computing programs across the country examined the context in which 1:1 programs impact student achievement the most (Holcomb, 2009). This review found that students that participated in 1:1 programs "earned significantly higher test scores and grades for writing, English-language arts, mathematics, and overall grade point averages than students in non-1:1 programs" (p. 50). However, many large-scale evaluations produced mixed or no achievement gains in 1:1 computing programs (Goodwin, 2011). Other research focused on practices that were found to be correlated with technology positively affecting student achievement. Means (2010) found common school level practices associated with higher achievement such as a consistent instructional vision, principal support, teacher collaboration around technology, and satisfactory on-site technical support. A similar study by Goodwin (2011) found that there were nine practices in 1:1 technology programs associated with higher levels of achievement. According to Goodwin, the top three factors were:

1. Ensuring uniform integration of technology in every class.
2. Providing time for teacher learning and collaboration (at least monthly).
3. Using technology daily for student online collaboration and cooperative learning. (p. 79)

Both Means's (2010) and Goodwin's (2011) studies cited teacher learning and collaboration as being associated with higher student achievement in 1:1 technology programs. This is significant because the literature regarding best practices in implementing 1:1 computing programs supports this conclusion as well and are explored in more detail in this review. In summary, the research into the effect 1:1 computing programs can have on student achievement has several dimensions:

- studying how 1:1 technology is used when positive student achievement results are detected
- studying the impact on student achievement by subject area
- studying how 1:1 programs are implemented and supported

This section of the review will examine the subject area effects of 1:1 programs and how the technology is used. The next major section of the review will explore the implementation and support of technology integrated education.

Writing

The literature reveals writing to be the subject most significantly impacted by 1:1 computing programs. One study indicated that students in 1:1 programs showed a 22% increase in meeting performance standards in one year (Jeroski, 2003 as cited in Holcomb, 2009). Researchers found that part of the reason for this increase was due to students spending more time using their laptops to write, edit, and reflect on their writing (Holcomb, 2009). Similar positive results were found regarding standardized test scores on the Maine Educational Assessment (MEA). Maine started a 1:1 computing initiative in 2002 supplying all teachers and students in grade seven and eight with a laptop computer. A study was conducted comparing MEA writing scores before the implementation of 1:1 computing in 2000 to those in 2005, three years after the implementation. Silvernail and Gritter (2007) write:

> Results indicate that in 2005 the average writing scale score was 3.44 points higher than in 2000. This difference represents an Effect Size of .32, indicating improvement in writing performance of approximately 1/3 of a standard deviation. Thus, an average student in 2005 scored better than approximately two thirds of all students in 2000. (p. i)

A multi-site case study by Warschauer (2008) examined how students used laptops for writing. Warschauer observed that laptops were used during all stages of the writing process. Prewriting activities utilized the Internet for research and drafts were primarily done on the computer. Students benefited from computers during the rewriting phase in particular because teachers could more quickly read papers and return them to students with feedback (Warschauer, 2008). There was also more observable collaboration between the students while writing with laptops in the multi-site case study.

A quantitative study conducted over a period of three years across five 1:1 settings and two non 1:1 comparison settings found evidence that the 1:1 computing program led to measurable changes in teacher practice, student achievement, and student engagement (Bebell & Kay, 2010). One component of this research focused on the grade 7 writing component of the Massachusetts Comprehensive Assessment System (MCAS) by comparing computer written responses to paper and pencil responses on MCAS aligned writing prompts. The results showed that students responding using a computer wrote both longer and more highly scored essay responses than students responding to the same prompt using paper and pencil (Bebell & Kay, 2010). Additionally, “both the Topic Development and Standard English Conventions score difference observed between laptop students and paper/pencil students were found to be statistically significant" (p. 45).

Reading

Research shows that 1:1 computing programs change the teaching and learning of reading in several ways. Warschauer (2008) found that in 1:1 settings, reading instruction featured more scaffolding, epistemic engagement, and page to screen. Scaffolding is the process of providing students support as they read so that they can better understand difficult material. In the 1:1 setting, Warschauer noticed that the most common way this happened was when students were directed to websites that could provide background information to aide in comprehension. Other computer-aided scaffolding observed in the study included online dictionaries, graphic organizers, and text-to-speech software. Epistemic engagement in the context of Warschauer's study (2008) refers to literacy activities that have students work together to interpret meaning from text. The study found that the laptops lent themselves to a variety of such activities like analyzing short stories through online discussion forums and writing book reviews. Finally, page to screen simply means the observation of higher levels of reading activity in the 1:1 classrooms. For example, students were frequently given assignments which required the reading of online material to complete both in language arts classes and across the curriculum (Warschauer, 2008).

As systematic review of mobile literacy learning between 2007 and 2019 examined the impact of 1:1 computing technology on the literacy domains of comprehension, phonics, fluency, and vocabulary (Eutsler et al., 2020). This review found that reading comprehension was the most widely examined domain. Researchers observed that students who used eReaders showed significantly higher comprehension scores than students who read printed books (Hsiao & Chen 2015 as cited in Eutsler et al., 2020). Researchers noted that problem-posing while reading interactive digital books significantly improved students' comprehension (Sung et al., 2019 as cited in Eutsler et al., 2020). Student-centered reading comprehension activities on the iPad were also found to increase student achievement in reading comprehension (Moon et al., 2017 as cited in Eutsler et al., 2020). Finally, a meta-analysis by Cho et al. (2018) affirms the positive effects 1:1 technology has on student achievement in the area of language learning. The findings are summarized as follows:

> The result of a medium sized overall positive effect of using mobile devices on language acquisition and language-learning achievement confirmed that the use of mobile devices could facilitate language learning. These results were consistent with other research findings regarding the effects of mobile devices on subsequent language-learning skills, such as vocabulary and general language acquisition. In addition, the result connected with recent systematic reviews and meta-analyses. (p. 12)

Mathematics

In the area of mathematics, 1:1 computing programs have allowed for the implementation of Mobile Leaning Interventions (MLI). In this context, MLI refers to student use of a computing device to practice or drill math facts. A study by Kiger et al. (2012) examined the student use of iPods on various math applications to practice multiplication. This quantitative study involved four classrooms, two of which used math applications on iPods for math multiplication practice in addition to traditional techniques. The other two classes only used "business as usual techniques such as flashcards, math games, fact triangles, and number sequences" (Kiger et al., 2012, p. 71). Pre and post assessments were administered to all four classes. The researchers found that students that used MLI in addition to traditional math fact practice methods significantly outperformed students that only used traditional methods. The results suggest that combining traditional math curriculum elements with mobile devices may be a cost-effective way to improve students achievement (Kiger et al., 2012).

The research on the impact of 1:1 computing devices on mathematics achievement is mixed. A study similar to Kiger et al. (2012) was conducted by Carr (2012) in two rural Virginia elementary schools. Carr's study examined the use of 1:1 iPad use on 5th-grade students' mathematics achievement. Over a nine-week period, students were divided into two groups. One group used the iPads for daily math intervention while the control group did not. A 50-question multiple choice pre and post assessment aligned to the math curriculum of the Virginia Standards of Learning (SOL) state assessment was given to all participants. Although the experimental group scored slightly higher than the control group on the post assessment, the iPad intervention did not have a statistically significant impact on students' mathematics achievement (Carr, 2012). Carr suggests that the study's results do not dismiss the usage of 1:1 computing devices in the math classroom, but they do indicate that additional investigation is warranted.

Other studies into the effect of 1:1 technology on math achievement have focused on geometry and the emerging use of *Augmented Reality* (AR) technology. This is because AR can help the students with concepts such as spatial awareness by visualizing geometric concepts (Cai et al., 2019). For example, Rohendi and Wihardi (2020) studied the use of an Android *Mobile-Based Augmented Reality* (MB-AR) application that allows users to explore the characteristics of geometric shapes such as cuboids. The application displays the cuboid as a three-dimensional graphic that can be manipulated by students to identify its parts including the sides, ribs, diagonal, and diagonal plane. Students can also use the application to learn the formula to calculate the area and volume of the cuboid. Their study concluded that MB-AR effectively contributed to the growth of students' ability to visualize, think spatially, and model geometric concepts in solving problems, (Rohendi & Wihardi, 2020).

A study by Cai et al. (2019) explored the effect of 1:1 AR technology on higher level mathematical concepts in statistics such as probability in a junior high school setting. This study used an AR application called Seven to gamify the concept of probability. The Seven application is a simplified Blackjack game that simulates the rolling of dice. The players take turns and the first player to score seven wins. Pre and posttests aligned to the school’s math curriculum were administered to all participants. The study found that the use of AR enhanced both student motivation and achievement in mathematics. The results were also consistent with other research that found AR to positively affect student achievement in science (Li et al., 2016 as cited in Cai et al., 2019).

Science

Research into the effect of 1:1 computing has on K-12 science achievement is not as abundant as studies involving writing, reading, and mathematics. Also, the literature regarding the impact 1:1 computing programs have on K-12 science achievement is often comingled with or treated as tangential to the 1:1 research in the areas of writing, reading, and math. One such study by Dunleavy and Heinicke (2007) was conducted in an urban middle school in a mid-Atlantic state. This study assessed the impact that a 1:1 laptop program had on math and science achievement on the state standardized tests. The research involved a randomly selected treatment group assigned laptops and a control group without laptops. The study occurred over a three-year period and involved 300 students in grades sixth through eighth and 12 teachers. Preexisting state standardized test scores of the students as fifth graders were compared to subsequent state standardized test scores. The researchers observed that the use of the laptops in the treatment group became more integrated into instruction each year as students and teachers gained familiarity with the technology. A primary finding was that the laptop treatment group science scores showed a statistically significant increase over the control group (Dunleavy & Heinecke, 2007). However, the study also concluded that there was no significant effect on the posttest math scores between the laptop treatment and control groups.

There have been studies done investigating the potential impact Artificial Reality (AR) has on the teaching and learning of science. These studies are like the previously discussed math AR studies in that they often deal with teaching concepts related to spatial relations. For example, Kirikkaya and Basgül (2019) researched the use of AR to teach concepts associated with the solar system in Grade 7 science. This experimental study utilized Solomon Four-Groups Design model, which is effective at controlling for both internal and external validity (Fraenkel & Wallen, 2009 as cited in Kirikkaya & Basgül, 2019). The researchers used pre and posttests to assess both student achievement and motivation to learn about the solar system. Students were divided into experimental and control groups. The control groups were taught the solar system using traditional text and lecture methods. The experimental groups had AR applications integrated into their instruction about the solar system. The researchers describe what they feel is a primary benefit of teaching with AR:

> The "Solar System" subject was taught with iSolarsystem and Space 4D AR applications in the experimental groups. One of the best achievements of these AR applications was that they showed very well that the planets are turning around the sun in a certain orbit. Instead of learning the features of the planets from the books in two-dimension, students have learned many of their features from the very beginning, such as proximity to the sun, satellite numbers, magnitude, rotation speeds around orbits, daily temperature differences and number of days to complete one revolution around the Sun. Moreover, students who studied the rotations of the Sun, the Earth, and the Moon with the application of "iSolarsystem" AR, could better perceive the concepts of time such as a day, a year, a month. (Kirikkaya & Basgül, 2019, p. 367)

In their discussion of the results, Kirikkaya and Basgül (2019) note that AR technology appears to be effective at attracting the attention of learners and activating them in the learning process. They also state that AR helps the students to visualize and understand difficult spatial concepts related to the study of space. They conclude "that using augmented reality applications in science teaching significantly contributes to the improvement of students' achievement and motivation" (Kirikkaya & Basgül, 2019, p. 376).

Summary – 1:1 Student Technology

Many studies in the literature conducted in the earlier stages of 1:1 computing initiatives showed it had a mixed to limited impact on student achievement. Doran and Herald (2016) write that previous studies have "shown that even when technology is present in classrooms, teachers are slow to transform their practice, instead using technology primarily to make administrative tasks and existing forms of instruction more efficient" (p. 11). A more recent meta-analysis conducted by researchers at Michigan State University looked at a mix of nearly 200 quantitative and qualitative studies that examined the effect of 1:1 technology on student achievement, teaching, and learning. This meta-analysis concluded that there was a small but statistically significant increase in achievement in student 1:1 laptop programs in the areas of English language arts, writing, math, and science (Zheng et al., 2016). In addition to looking at the quantitative impact 1:1 computing had on test scores, the meta-analysis looked qualitatively at the broader effects brought about by 1:1 computing environments with regards to teaching and learning. Doran and Herald (2016) summarized the findings of Zheng et al. (2016):

- A 1-to-1 laptop environment often led to increased frequency and breadth student technology use, typically for writing, Internet research, note-taking, completing assignments, and reading.
- Students used laptops extensively throughout the writing process, expanding the genres and formats of their work to include writing for email, chats, blogs, wikis, and the like.
- Student-centered, individualized, and project- based learning appeared to increase in at least some instances of 1-to-l laptop rollouts.

- Student-teacher communications (via email and Google docs, for example) and parental involvement in their children's schoolwork increased in some instances.
- Students expressed "very positive" attitudes about using laptops in the classroom, as findings consistently showed higher student engagement, motivation, and persistence when laptops were deployed to all students.
- Students' technology and problem-solving skills improved, and their ownership of their own learning increased, according to some evidence.
- There were mixed findings on whether 1-to-l laptop programs helped overcome inequities among students and schools. (p. 11)

The qualitative findings of Michigan State University's meta-analysis (Zheng et al., 2016) suggest a larger implication of the effects of 1:1 computing programs. That is, they have a transformative influence on the entire educational environment. The technology changes how students learn by changing how they interact with content. The way teachers use technology to teach is also affected. Communication between students, teachers, and parents is increased. Finally, the literature indicates that the longer students and teachers are exposed to a 1:1 computing environment, the more the technology becomes an integral part of the teaching and learning process. All of this leads to the modern realization that education has become a very technology-integrated endeavor.

Technology-Integrated Education

Effectively integrating 1:1 computing into the educational environment involves much more than simply distributing a computing device to every student and teacher. Lamb and Weiner (2021) write "giving students and teachers devices does not itself foster change, but requires attention to structures and systems by all actors in the system"

(p. 336). In other words, physical infrastructure, device selection, cost, technical support, professional development, program goals, and program evaluation are all important considerations. All of this requires extensive planning. This section of the literature review focuses on research into these aspects of implementing 1:1 computing programs.

Physical Infrastructure

Lamb and Weiner (2021) conducted a study in four school districts with 1:1 computing programs during the 2018-2019 school year. They found that all the districts needed to invest a considerable amount of time, planning, and funds into building out adequate wireless networks to support the technology. This included supplying hotspots to students that needed them to ensure they had Internet connectivity to complete assignments at home. As one of the district technology directors in the study explained, “any district that does not invest in the [wireless] infrastructure is not going to be able to get to that [1:1] program, get to that level” (Lamb & Weiner, 2021, p. 341). Students involved in a different four-year study of 1:1 iPad use also cited dependable internet as being important to a smooth-running class (Curry et al., 2019). Another critical consideration when expanding a wireless network to accommodate 1:1 computing is obtaining adequate Internet bandwidth to accommodate the increased traffic to the web (Keane & Keane, 2017). Finally, for students in very rural areas, special considerations may be necessary due to long bus rides and the lack of internet, even with a hotspot (McClure & Pilgrim, 2020).

Device selection is a key consideration for 1:1 programs discussed in the literature. A study of how one-to-one initiatives were conducted in rural public K-12 educational settings in a mid-western state found that decisions regarding devices were often made by small committees with limited representation (Vu et al., 2019). According to Vu et al., cost was the primary consideration in committee device selection decisions with device management, durability, and ease of use often being secondary. Participants interviewed in this study stated that this was a program limitation, advocating for a more representative committee sample in such decisions. Included in durability considerations is device battery life and having a reliable system to ensure the devices are recharged before each use (Khlaif, 2018). The age level of the students also influences device choice. For example, elementary schools tend to select iPads or tablets for their one-to-one initiatives, whereas higher level grades preferred laptops or Chromebooks to facilitate ease of typing (Vu et al., 2019). One of the participants in the study reflected in an interview “Do not focus on the brand of the product or price, focus on what is best for the students” (Vu et al., 2019, p. 65). Similar observations were made in the Lamb and Weiner study (2021), “While price, durability and availability were major considerations, device fit for the educational programs and goals were paramount” (p. 341). Lamb and Weiner (2021) also write that the needs of different age groups were considered to prepare students for the technology they would encounter as they grew.

Providing adequate technical support in terms of additional staff and systems is essential to successfully implementing a 1:1 computing program (Cole & Sauers, 2018). Placing a thousand or more individual computing devices into an average size school building requires a significant amount of technical support. Therefore, increasing technical staff to support a large volume of computing devices that require periodic maintenance and updates as well as trouble shooting and repair when not working properly is crucial. Also deployment of technical support staff to assist staff and students should be prioritized through a referral system so that support is available in a timely manner (Love et al., 2020). Research has shown that the ready availability of quality technical support and training can have a significant positive influence on adopting and integrating 1:1 technology into classroom instruction (Khlaif, 2018). Conversely, Khlaif notes that negative attitudes toward tablet use in classroom instruction caused by hardware and software technical challenges, lack of infrastructure, unavailability of technical support, and lack of teacher training can pose a significant implementation obstacle. Although teacher technology training often starts with the technical staff providing instruction on general operation of 1:1 devices, navigating the network, and basic device troubleshooting, a more systemic approach to professional development in 1:1 environments is recommended in the literature (Curry et al., 2019; Keane & Keane, 2017; Ross, 2020).

Professional Development (PD)

Research has demonstrated that more obstacles to the instruction process are encountered when teachers do not receive adequate professional development (PD) when implementing 1:1 computing programs (Bebell & Kay, 2010). With regards to learning to teach with 1:1 technology, Corey (2019) writes that the "Implementation of new ideas and initiatives requires change. Implementing change requires more than time; it also requires increased training and allowing individuals to learn and grow" (p. 311). Research into adult learning affirms that learning to teach with technology requires effective professional development to be "seamless, technology enabled, comprehensive, and career spanning" (Rock et al., 2016. p. 98 as cited in Love et al., 2020). The traditional models of one-time PD sessions are simply not adequate to change instruction in the classroom (Love et al., 2020). Teachers need an opportunity to apply newly acquired technology teaching skills with access to ongoing support and additional training to continuously improve (Darling-Hammond & Richardson, 2009).

Digital Competency

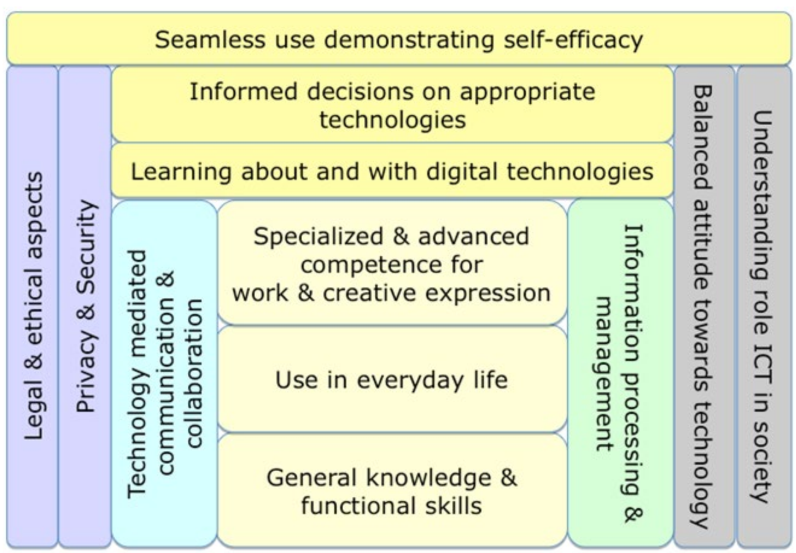
Preparing teachers to utilize computers in the classroom has traditionally focused on developing digital competency. That is, preparing teachers to properly use and evaluate digital resources, tools and services, and then apply these skills to teaching (Glister, 1997 as cited in Falloon, 2020). Over the past 20 years, the explosion of new technologies, abundant Internet access, and the increase of mobile devices has rendered this approach inadequate (Falloon, 2020). Teaching with current technology requires a paradigm shift in thinking about how teachers approach teaching and the learning environment (Lawrence, 2019). In other words, we must not simply practice traditional classroom pedagogy using computers. Lawrence (2019) writes, "Instead we must think of new ways of doing new things with these new tools" (p. vii). This requires a more inclusive view of what digital competency means.

A study was commissioned by the European Commission's Joint Research Centre (ECJRC) to develop a more comprehensive framework for what constitutes digital competency in the current environment with information technology becoming so prevalent. The study involved a group of 95 experts from a broad sampling of nations. The study's results indicate that digital competence is built up of knowledge, skills, and attitudes pertaining to 12 different areas (Janssen et al., 2013).

Figure 1 places all twelve of what the ECJRC researchers refer to as *digital competence building blocks* into a hierarchy to visualize how they interact with each other to encompass the total concept of digital competency (Janssen et al., 2013). This research suggests that a comprehensive approach to developing technology PD for teachers should consider where teachers are in terms of the many facets of digital literacy and scaffold training accordingly. For example, teachers in schools with 1:1 student computing initiatives often report higher levels of personal technology competency and classroom integration of learning technologies (Sauers & McLeod, 2018). In this instance, PD would be best focused on digital competence building blocks closer to the top and center of Figure 1. Conversely, teachers just beginning to teach in a 1:1 learning environment would benefit the most from instruction beginning in the lower center of the diagram. The extreme left and right sides represent overarching concepts to be grown.

Figure 1

Digital Competence Building Blocks



Professional Development Models

The research indicates that one-time PD sessions that simply demonstrate new technologies to teachers rarely results in a significant change in classroom instruction

(Love et al., 2020). Technology PD should be designed that assesses what each individual or group of teachers needs and allows for flexible hands-on experiences during training sessions where teachers have an opportunity to see how the technology can be applied to their classroom or subject area (Cook et al., 2017 as cited in Love et al., 2020). Research also indicates that the delivery of technology PD should be ongoing, anticipate and diagnose educators' needs, provide differentiated support, be collaborative, and closely involve building principals (Hilaire & Gallagher, 2020). There are several PD delivery structures that meet the aforementioned criteria such as professional learning communities, online professional learning networks, train-the-trainer, and coaching.

Professional Learning Communities (PLC). Groups of teachers work together to learn about and share resources on a particular topic (Love et al., 2020). It can be structured so that teachers of similar subjects or grade levels are grouped together so they can collaboratively share and explore pedagogy with a specific technology or tool (Love et al., 2020).

Professional Learning Network (PLN). An online variation of PLCs, a PLN "has been described as a synchronous or asynchronous online platform for individuals to collaboratively engage in critical thinking and discussions that lead to mutual reflection and understanding of selected issues (Garrison, 2007 as cited in Cook et al., 2017, p. 110).

Train-the-Trainer (TTT). Key staff members are trained with the expectation that they will in turn train their colleagues. This model can be combined with PLCs and PLNs to ensure a steady flow of new technology and pedagogy (Love et al., 2020).

Coaching. Individually coaching teachers provides customized, supportive, and just-in-time training (Ismajli et al., 2020). Research indicates "instructional coaching has emerged as a major strategy for improving teaching practices and, in turn, student learning and achievement. Good coaching helps teachers to move from where they are to where they want to be" (Aguilar, 2013 as cited in Ismajli et al., 2020, p. 1308). Coaching can also be integrated into the PLC, PLN, and TTT models.

Research indicates that it is essential that school leaders provide vision, guidance, and support for technology-integrated education for it to be successful (Lewis, 2016; Raman et al., 2019; Sauers & McLeod, 2018). The research also suggests that combining TTT and coaching with PLCs and PLNs can be very effective in providing educators with ongoing access to differentiated PD to maximize the use of technology in their classrooms. Durff and Carter (2019) found that a team approach among administrators, technology support personnel, and teachers resulted in the strongest technology-integrated education. This is particularly significant to this Doctoral Capstone Project because it evaluates the effectiveness of the professional development provided to WASD teachers for its 1:1 computing program, which has been delivered in the ways positively cited in the literature e.g., PLCs, PLNs, TTT, and coaching. For example, the District employs several Technology Integrators in each school building K-12. The Integrators are tech savvy teachers that provide ongoing coaching, specific subject/tool training, and facilitate PLCs after school.

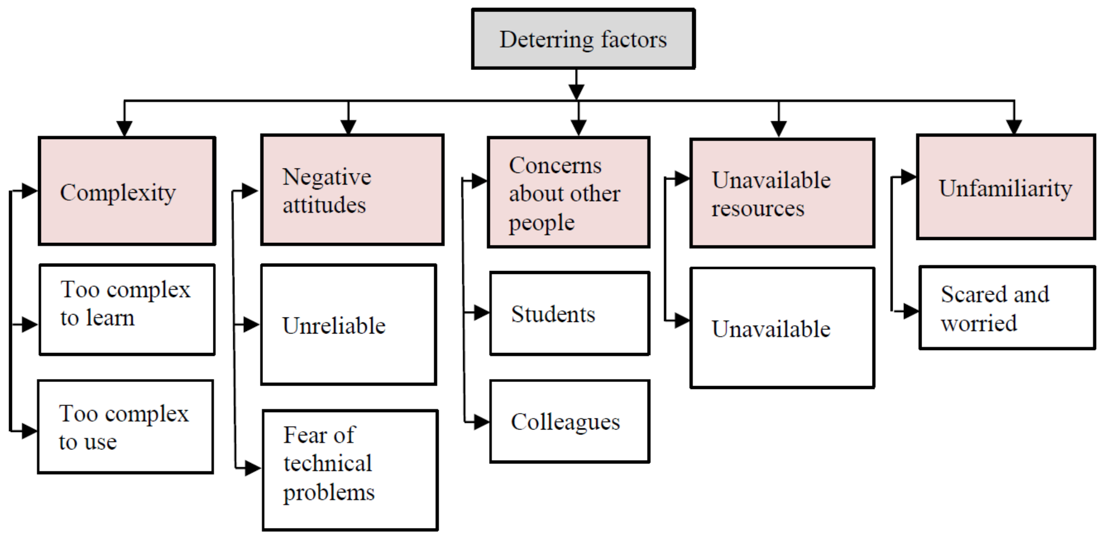
Technology Acceptance Model (TAM)

When microcomputer technology started to permeate the workplace and schools in the 80s and 90s, research was conducted by Davis (1989) to investigate why some individuals adopted technology in the workplace while others did not. This study was organized around the hypothesized concept that adoption and use of technology is affected by perceived usefulness and perceived ease of use. Davis defines perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p. 320). In contrast, Davis defines perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort" (p. 320). Results of the study confirmed that both perceived usefulness and ease of use were significantly correlated with self-reported indications of technology use but that perceived usefulness was the stronger of the two indicators (Davis, 1989). This suggests that individuals are willing to endure a learning curve with technology if there is a perceived benefit or payoff, which has significant implications for 1:1 computing program implementations. So, benefits of 1:1 programs should be clearly articulated to teachers in specific terms e.g., personalized learning, improved student writing, multiple remediation opportunities, increased efficiencies for lesson preparation and delivery, increased ways in which students can collaborate with each other, better teacher-parent communication, etc. Otherwise, teachers may lose interest during implementation when inevitable complications occur as with anything new and complicated.

The research of Davis has subsequently been used to evaluate why some teachers integrate technology into instruction while others do when given access to technology (Alsharida et al., 2021; Cabero-Almenara et al., 2021; Kampookaew, 2020). The literature indicates that how teachers perceive technology can significantly impact their willingness to integrate it into instruction. Kampookaew (2020) summarized her findings of the primary reasons teachers are deterred from integrating technology into instruction in Figure 2. This research further indicates that thorough planning, reliable infrastructure, and effective professional development are essential to ensuring the effective integration of technology and teaching.

Figure 2

Deterring Factors



1:1 Program Evaluation

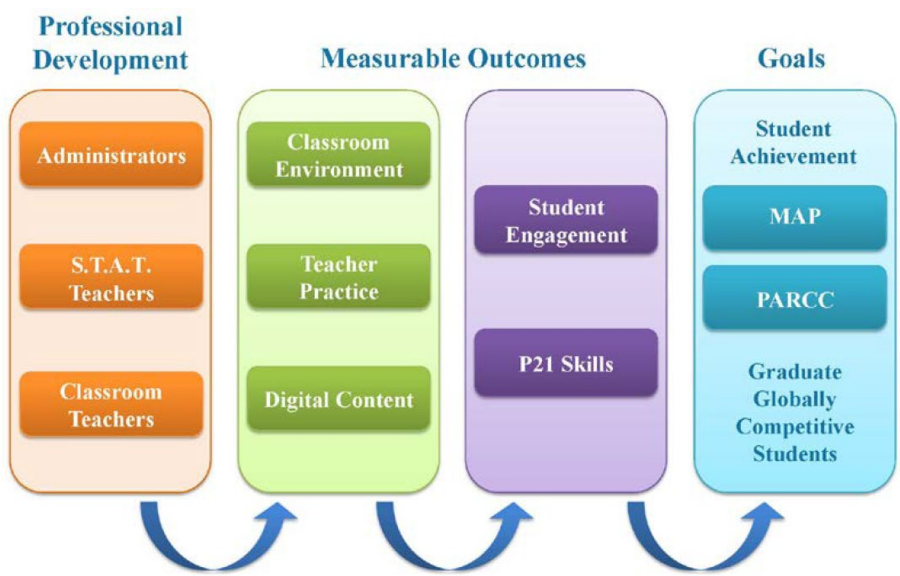
A prevalent theme in the research into integrating 1:1 technology into classrooms is justifying the costs of such programs by showing that they boost grades or student achievement on standardized tests. Research has shown though, that using student achievement on standardized tests or other measures in specific subject areas can produced mixed results, especially from one year or subject to the next (Curry et al., 2019). Overall however, meta-analyses have shown that 1:1 programs produce a small but significant impact in most subject areas (Zheng et al., 2016). Consequently, justifying the 1:1 technology-integrated education solely on the promise of a significant increase in student achievement may not provide the needed level of justification.

There has been research done to study the effectiveness of 1:1 programs that take a more comprehensive approach to examining the effects of the programs beyond just looking at grades and standardized achievement scores. One such study was conducted by John Hopkins University (Morrison et al., 2019) over a five-year period in the Baltimore County Public School (BCPS) system to assess its 1:1 computing program initiative titled Students and Teachers Accessing Tomorrow (S.T.A.T.). The study designed an evaluation tool to look at the S.T.A.T. program holistically from the perspective of professional development, measurable outcomes, and goals.

The S.T.A.T. evaluation model is depicted in Figure 3 (Morrison et al., 2019, p. 6). The evaluation assesses the effectiveness of the S.T.A.T program using several metrics or inputs. On the left, close ended survey data were used to assess the effectiveness of professional development and address the question "What are the roles, perceptions, and best practices of S.T.A.T. teachers" (Morrison et al., 2019, p. 6). In the middle of Figure 3, intermediate measurable outcomes are evaluated by the OASIS-21, a standardized classroom observation instrument which is designed to assess the classroom environment, student engagement, and 21st century skills such as problem solving and project bases instruction. Finally on the right, student achievement is assessed by examining results from two standardized assessments, the Partnership for Assessment of Readiness for College and Careers (PARCC) and the Measure of Academic Progress (MAP), which assesses achievement and growth in K–12 math, reading, language arts, and science. Both the MAP and PARCC are independent from the S.T.A.T. evaluation model meaning they were not developed for the study but rather are administered to students in Baltimore County Public schools each year.

Figure 3

S.T.A.T. Evaluation Model



A primary reason cited in the literature for implementing 1:1 programs is to change the way students learn and teachers teach. According to Cole and Sauers (2018), changes desired from 1:1 programs primarily include a focus on personalized learning, collaboration, student engagement, and project-based learning, which are very much aligned with the S.T.A.T. program goals. The strength of the S.T.A.T. evaluation model is that it provides a richer overall picture of the impact of the 1:1 program on the BCPS system in terms of anticipated outcomes. The S.T.A.T. 1:1 computing program evaluation (Morrison et al., 2019) found that:

- Overall student engagement is improved.
- Students' overall perceptions of the S.T.A.T. initiative and the personal devices is very positive.
- Modest evidence of instructional change with teachers making more extensive use of coaching and facilitating than teacher-led presentations.

- The most experienced S.T.A.T. classrooms were observed making more frequent use of higher-level questioning techniques, higher-order instructional feedback, collaborative learning activities, and flexible grouping arrangements.
- Activities emphasizing P21 skills were not observed very frequently.

Morrison et al. (2019) also writes that the evaluation yielded “mixed but overall positive trends for S.T.A.T. schools on MAP and PARCC assessments” (p. 41). Although the S.T.A.T. evaluation yielded mixed results, it found an overall positive effect attributed to the S.T.A.T. program aligned with program goals. This demonstrates the intricacies involved in examining how technology impacts teaching and learning. That is, success can be difficult to define and assess when it comes to technology-integrated education. The final section of this literature review explores one more aspect of the effect technology has on education by examining how technological knowledge, pedagogical knowledge, and content knowledge interact in the classroom.

Technology Integration Models

In a technology integrated classroom environment, technological knowledge, pedagogical knowledge, and content knowledge all overlap in ways that require a new approach or framework to conceptualize. These frameworks are frequently referred to as *Technology Integration Models* (Falloon, 2020). This section of the review is the most relevant to the Doctoral Capstone Project research because the use of 1:1 technology by WASD teachers is analyzed in the context of two of the most prevalent Technology Integration Models in the current literature: *Substitution, Augmentation, Modification, and Redefinition* (SAMR); and *Technological Pedagogical and Content Knowledge* (TPACK).

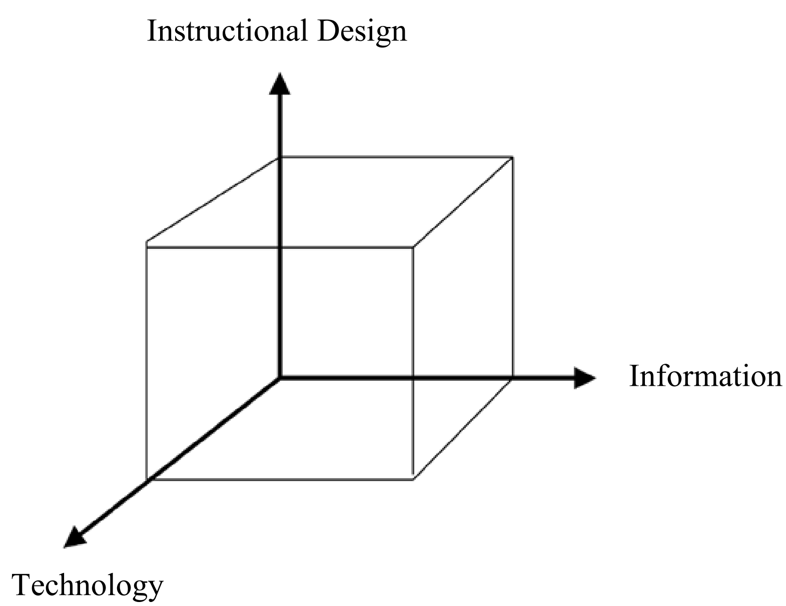
Information, Technology, Instructional Design (ITD)

One of the earlier attempts at comprehensively conceptualizing how technology knowledge, pedagogy, and content knowledge interacts in the classroom that appears in the literature is the research of Liu & Velasquez-Bryant (2003). Their work organizes technology-integrated instruction around a three-dimensional model depicted in Figure 4. They describe the model components:

> In the ITD system…the first dimension–*information* (I)–represents the learning or teaching content, and any supporting resources and materials. The second dimension–*technology* (T)–represents the hardware and software tools that can be used appropriately to support or enhance learning and teaching. The third dimension–*instructional design* (D)–represents a set of rules for instructional design. (p. 92)

Figure 4

The Three-Dimensional ITD Information Technology Integration System



The ITD technology integration model makes three major assumptions (Liu & Velasquez-Bryant, 2003):

1. Technology-based learning will never occur in any single dimension.
2. Technology-based learning will never occur in any combination of just two dimensions.
3. Technology-based learning only occurs as the result of the *integration* of all three components: Information (I), Technology (T), and Instructional Design (D). (p. 93)

A key finding in their research into ITD is that the *Instructional Design* component is what they refer to as the *missing link* (Liu & Velasquez-Bryant, 2003). They explain that teachers often focus on the I-T components without carefully considering the instructional design (D). Pointing back to their major assumptions, they write "any combination of two dimensions without inclusion of the third will not produce successful technology-based learning" (p. 98). Liu & Velasquez-Bryant clarify that overlooking instructional design is not intentional on the part of the teacher. They contribute the primary cause to what they refer to as the *technology life cycle*. Simply put, as teachers become familiar with a given technology tool and near instructional design integration after considerable effort, new technology appears that disrupts the completion of the process. In education, with the rapid advancement of available technology, there is pressure to adopt new technology to stay current. This cycle leads to incomplete technology integrated instruction. Liu & Velasquez-Bryant (2003) contend that if a well-developed integration design model is provided to educators, they will approach the instructional design component from the very start when using new technology. Research and development of technology integration models expands rapidly in the literature after the introduction of ITD with models such as TIP, TIM, and RAT (Mulyati, 2019). Most of the models start with the primary assumption that technology, information, and instructional design or pedagogy must all interact seamlessly for true technology-integrated instruction to occur.

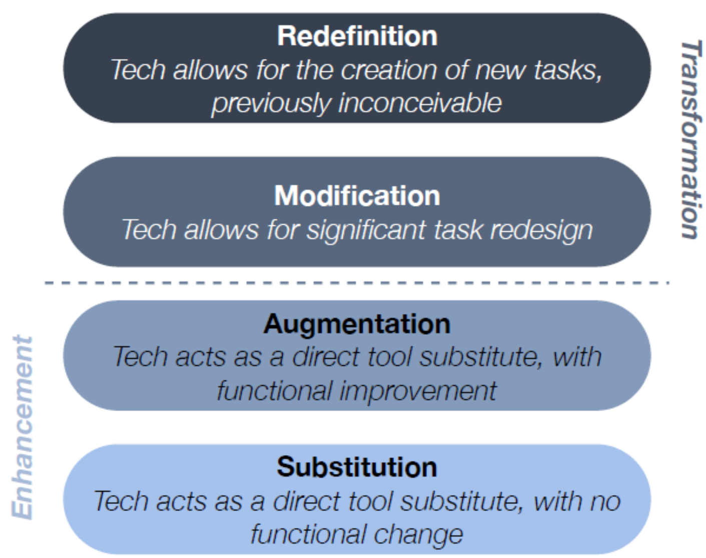
Substitution, Augmentation, Modification, and Redefinition (SAMR)

The SAMR framework was initially introduced by Puentedura in 2006 as part of a technology workshop, coordinated by the Maine School Superintendents Association, working with the Maine Department of Education, with funding from the Maine Learning Technology Initiative and the Bill & Melinda Gates Foundation (Puentedura, 2006). The SAMR model for technology integration aims to help teachers to make well-informed choices and decisions about the technology implementation process (Kurbaniyazov, 2018). SAMR is significant to this Doctoral Capstone Project because it will be one of the models used to assess how WASD teachers integrate technology into instruction. Specifically, teachers will be asked to self-report how technology is used in their classroom in terms of the SAMR framework.

The SAMR framework classifies technology use in teaching and learning into four categories and is depicted in Figure 5 (Puentedura, 2010). The four categories from bottom to top are *Substitution*, *Augmentation*, *Modification*, and *Redefinition*. Substitution is when technology serves as a direct replacement of a traditional practice. A simple example of Substitution would be students using a mobile device in class to take notes while a teacher is lecturing (Hockly, 2013). This involves no innovation or lesson modification and can just as easily be done writing in a notebook, although there is a slight enhancement in that electronic files can be more easily sorted and searched. Augmentation is a substitution, but with an improvement in the function (Caukin & Trail, 2019). For example, there are many mobile learning applications that feature the ability for students and teachers to interact with documents in a variety of ways by drawing, taking pictures, captioning, etc. Learning is enhanced because of the added functionality of customized information flow between the teacher and student.

Figure 5

SAMR Technological Levels of Use

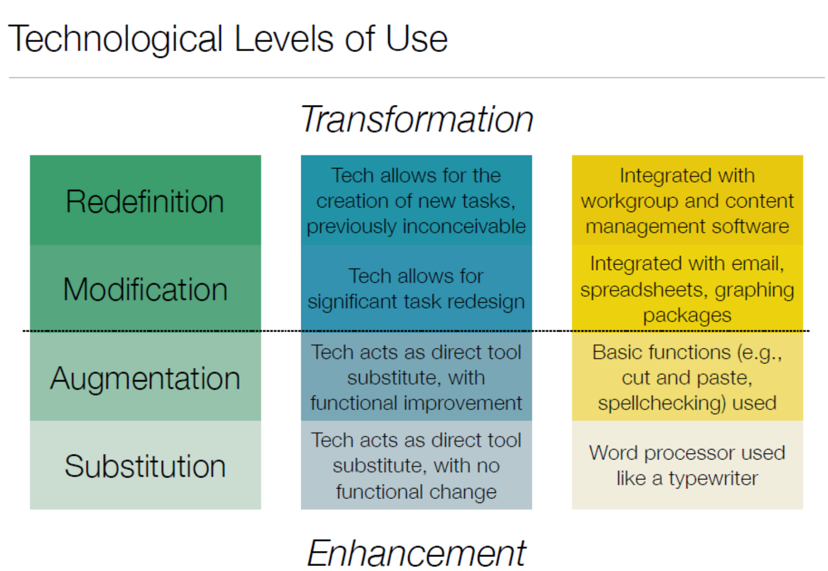


The SAMR model is like Bloom's taxonomy. A hierarchy is present indicating that more or higher-level technology integrated instruction translates into increased learning benefits (Hilton, 2016), although some research disagrees (Walsh, 2017). This does not mean that activities characterized as Substitution or Augmentation do not have value. In fact, they are necessary skills to reach the *Transformation* level activities. Figure 5 shows that Substitution and Augmentation occupy the lower *Enhancement* level of the SAMR hierarchy (Kurbaniyazov, 2018).

The top half of the SAMR model is referred to as Transformation and involves Modification and Redefinition. Kurbaniyazov (2018) states that instructional activities at this level are dependent on technology. In other words, Modification and Redefinition cannot be achieved without technology. An example of Modification would be having students create a multimedia presentation using iMovie and customized music produced in Garage Band (Caukin & Trail, 2019). Figure 6 provides additional classroom examples in the column on the right (Puentedura, 2006). At the top of the Transformation level, a Redefinition activity example would be students jointly working on quizzes or presentations in real-time where the responses are seen by all participants screens (Flanagan, 2016).

Figure 6

SAMR Levels of Use: Classroom Examples



After its introduction in 2006, Puentedura further refined the SAMR model. In 2012, the framework began to gain popularity among practitioners (Hilton, 2016). Many studies have looked at the effect each of the four technology use levels have on learning.

A multi-study review by Romrell et al. (2014) concluded "that every example at the redefinition level of the SAMR model was personalized, situated, and connected" (p. 87). This was not true of instructional examples at the lower levels of the framework (Romrell et al., 2014), although some modification level activities produced similar results. Again however, teachers and students must have skills and understand technology use at the lower levels of the SAMR framework before being able to put it all together at the redefinition level.

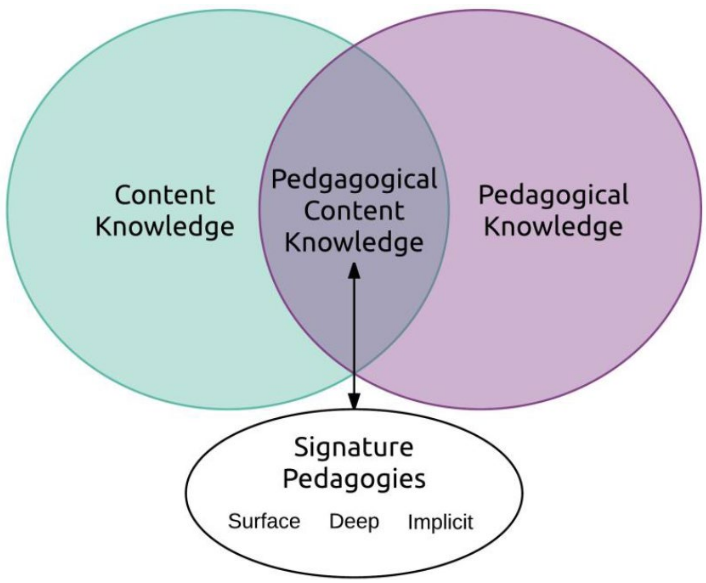
In a study applying SAMR to Grade 12 English classes, Handoko (2020) writes that the SAMR model provides steps on how teachers can integrate technology into instruction and enable students to develop and create. It is expected that the distribution of SAMR levels will vary throughout the school year as not all use of technology can be redefined in every lesson (Hilton, 2016). SAMR is one of several models that can assist teachers integrate technology into instruction. TPACK is another prominent framework in the literature for integrating technology. TPACK is the older of the two models and maintains the larger share of the literature, although both models continue to see exposure through conferences and new literature (Hilton, 2016).

Technology, Pedagogy, And Content Knowledge (TPACK)

The TPACK framework was originally presented by Koehler and Mirshra in 2007 at the annual conference of Society for Information Technology and Teacher Education (Koehler & Mirshra, 2014). TPACK builds upon the work of Shulman (1987) that puts *Pedagogical Content Knowledge* (PCK) at the center of what teachers do. PCK is the notion that a teacher transforms subject matter for teaching in a variety of ways by interpreting it and creating multiple ways to present it, taking into account the students' prior knowledge and ability level (Koehler & Mirshra, 2014). Figure 7 visualizes Shulman's concept of *Content Knowledge* (CK)*, Pedagogical Knowledge* (PK), and the intersection of both areas, *Pedagogical Content Knowledge* (PCK) (Shulman, 1987 as cited in Smith & Kanuka, 2018). Goradia (2018) explains that CK in Shulman's work refers to teachers' knowledge of the content or subject area and PK refers to teachers' understanding of teaching and learning.

Figure 7

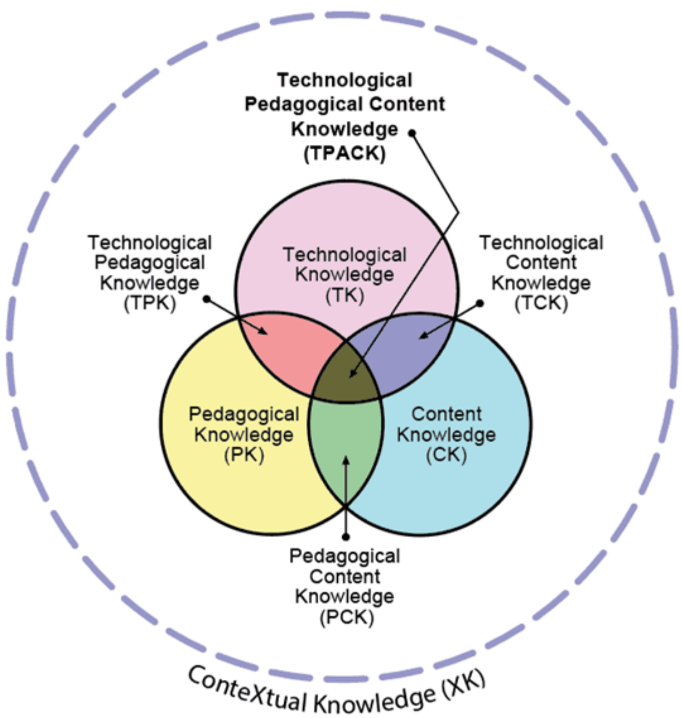
Pedagogical Content Knowledge and Signature Pedagogies



TPACK adds *Technological Knowledge* (TK) as a third area or domain to Shulman's original framework as depicted in Figure 8 (Mirshra, 2018). TK in TPACK refers to teacher's understanding of how to use various technologies (Schmidt et al., 2009). When TK is overlayed with Shuman's original three domains, three new domains are created at the intersections: *Technological Pedagogical Knowledge* (TPK), *Technological Content Knowledge* (TCK), and *Technological Pedagogical and Content Knowledge* (TPACK). The concept that the teacher transforms content to represent it in various ways to students using technology transforms the lesson content, pedagogy, and learning into something new and unique. The intersection of TK, CK, and PK collectively becomes TPACK. Figure 8 shows the TPACK intersection at the very center of the diagram, creating a total of seven domains. TPACK then, "refers to the knowledge teachers require for integrating technology into their teaching—the total package" (Schmidt et al., 2009, p. 134).

Figure 8

Revised TPACK Image



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The TPACK framework was developed to help "conceptualize and structure theories and transform teachers' teaching pedagogy and practice" (Koehler & Mishra, 2006 as cited in Hsu & Chen, 2019, p. 2). In other words, TPACK is useful because teaching with technology presents a unique pedagogical challenge because it is unlike traditional pedagogical technologies that are characterized by specificity (Koehler & Mirshra, 2014). A simple example would be the use of a balanced scale used in a science class. The scale's only function is to accurately weigh objects. Contrast this with technologies such as computers, handheld devices, and software that are protean, meaning that they are usable in many different ways (Papert, 1980, as cited in Koehler & Mirshra, 2014). Teaching with technology proposes unique challenges because it can be integrated in many ways depending on the subject, content, and context, context, making it very complex. Koehler and Mirshra (2014) write that, "understanding approaches to successful technology integration requires educators to develop new ways of comprehending and accommodating this complexity" (p. 62). Walsh (2017) adds that "TPACK encourages teachers to think beyond technology as an add-on and consider how technology supports the content being taught, and how pedagogy might change when teaching with technology" (p. 30).

Theoretical frameworks such as TPACK describe an idea or concept that is based on theory, while technology integration models like SAMR aim to guide instruction (Eutsler, 2020). Not surprisingly, "TPACK has become very popular among educational researchers, and SAMR has become very popular among practitioners" (Tri Mulyati, 2019, p. 29). Hilton (2016) describes the difference in her research:

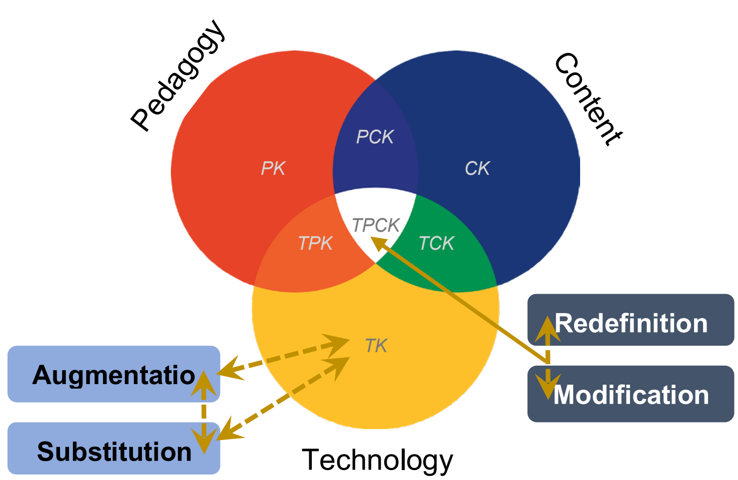
> SAMR appears to most easily connect to student-centered design in that each activity is examined for specific opportunities to imbed technology in a manner that improves the independent learning capacity of the students. Alternatively, TPACK appears to more easily align with teacher-centered instructional design

philosophies, given that when operating in the central space of TPACK technology, pedagogy, and content are filtered through the teacher into learning opportunities that capitalize on emerging technology. (p. 72)

Despite their differences, there has been work done by Puentedura and others to explore the relationships between SAMR and TPACK. Puentedura (2010) observed connections between TK and the Augmentation and Substitution level of SAMR. Whereas Definition and Modification in SAMR occur when the lesson technology, pedagogy, and content knowledge merge in the center TPACK domain as depicted in Figure 9 (Puentedura, 2010; Puentedura, 2013). The relationship between the SAMR and TPACK framework is significant to this Doctoral Capstone Project because it serves as a researched based context from which to evaluate WASD teachers' level of understanding of technological knowledge as it relates to pedagogical and content knowledge. This will provide insight into the strengths and challenges of the faculty that can be used to inform future professional development to improve teacher practice and student achievement in a 1:1 computing environment.

Figure 9

Relationship Between SAMR and TPACK Frameworks



Both the SAMR and TPACK frameworks have value for several reasons. One, for 1:1 integrated computing programs to be effective, research indicates that they should be coupled with good theory (Mulyati, 2019). Two, with the constant development of new technologies, a theoretical framework can serve as a tool to determine if new technology is being used simply because it's novel and trendy or because it adds legitimate educational value to teaching and learning (Parsons, 2020). Three, educational technology integration models provide a focused approach to help teachers specifically consider how to integrate technology to maximize their use of resources and ultimately improve student achievement (Hilton, 2016). And finally, a theoretical framework can be used to assess how and at what level of integration teachers are using 1:1 technology in their classrooms. This Doctoral Capstone uses the SAMR and TPACK models as a lens for examining the 1:1 technology initiative in the WASD.

Summary

The first computers appeared in schools as part of federally supported initiatives in the 1950s. However, widespread use of computers in schools did not occur until the 1980s with the introduction of microcomputers that were powerful and affordable. The increase of computers in schools throughout the 80s and 90s brought a steady growth in educational use. Early use focused on drill-and-practice programs, teaching of programming languages such as BASIC, and applications such as word processing and spreadsheets.

Near the end of the 20th century the growth of the Internet had a transformative effect on computer technology. In the 2000s, Web 2.0 applications such as wikis, weblogs, podcasts, and streaming media became widely available and were easily learned by teachers and students. These information and communication technologies brought a large number of benefits to education such as student-centered and self-directed learning, creative learning environments, and increased collaboration opportunities. The development of affordable microcomputers such as laptops and tablets combined with rapid Internet growth moved computers out of shared computer labs and spaces and directly into classrooms. This led to the growth of 1:1 computing programs in the 2010s where students were each given access to or assigned a microcomputing device.

Research focused on the effect of 1:1 computing programs have on student achievement in the 2010s is somewhat mixed with some studies showing little to no impact while many others found significant improvement in writing achievement and small but positive gains in reading, math, and science. The research also indicates an overall positive impact on student achievement in schools that have a focused instructional vision, strong leadership, teacher collaboration, ongoing professional development, solid infrastructure, and uniform integration of technology in every classroom. In addition to looking at the impact 1:1 computing has on test scores, other research revealed that 1:1 technology transforms the learning environment. For example, more individualized learning occurs, and students exhibit higher levels of engagement.

A review of the research regarding technology-integrated education indicates that it requires several things to be effective: Strong physical infrastructure and technical support; ongoing collaborative and embedded professional development that's based on teacher needs using research-based delivery models shown to be effective such as PLCs, train-the-trainer, and coaching; and a program evaluation that's based on a conceptual framework that assesses how teachers integrate technology. These areas are important to this Doctoral Capstone Project because teacher needs, professional development, and how teachers use technology will be examined in the WASD 1:1 technology initiative.

The literature suggests that for 1:1 programs to be effective, they should utilize a researched based framework. The most prominent frameworks in the literature are the SAMR and TPACK models. Both frameworks break down integration into components. The TPACK model describes the concepts involved with how technological knowledge interacts with pedagogical and content knowledge. The SAMR model is more educator and learner centered describing levels of technology use and integration in the classroom. Research indicates that the models are complimentary in that TPACK provides teachers a way to understand the complex process of technology-integrated teaching while SAMR guides teachers with the implementation. This Doctoral Capstone Project studies the WASD 1:1 technology initiative using the SAMR and TPACK frameworks.

CHAPTER III

Methodology

The literature review revealed that technology has created periods of disruption and change in education that can be traced back to ancient civilizations. The most dramatic period of change began in the middle of the 20th century with the development of affordable personal computers and widespread proliferation of the internet. This led to schools dramatically increasing the number of computers in the 2000s in a push to provide every student with access to an internet-capable mobile computing device. Laptop computers and other mobile technologies have become ubiquitous throughout schools across the nation. This is truer now than several years ago due to the COVID-19 pandemic that greatly increased the need for every student to have access to a mobile computing device to accommodate periods of remote learning. The EdWeek Research Center reported in June of 2020 that 1:1 environments started expanding and student access levels increased in response to the onset of the pandemic (Bushweller, 2020). This trend accelerated through 2021 as the United States and many other countries transitioned from face-to-face learning to remote education (Huck & Zhang, 2021).

During the 2014-2015 school year, the Wattsburg Area School District (WASD) began upgrading technology with the goal of moving the entire District to a 1:1 environment where every student in Grades K-12 is assigned a personal computing device. The process took six years and a considerable investment in technology infrastructure, computing devices, and professional development. The total estimated annual cost related to the 1:1 initiative now totals $720,000, which includes ongoing embedded professional development delivered by highly trained teachers called

Technology Integrators. Given such a significant investment, this study provided data that will be used to inform the District of the program's effectiveness and return on investment with the goal of improving technology-integrated instruction.

Purpose

The purpose of this Capstone Research Project is to assess the efficacy of WASD's 1:1 technology initiative. The data for this study were obtained via a secure online survey using Microsoft Forms that contained both Likert scale items and open-ended questions. The survey instrument was designed to capture data aligned with the study purpose and research questions as shown in Table 2. This included gathering teachers' perceptions of the effectiveness of instruction in a 1:1 environment and the professional development teachers received related to the program. To evaluate how often and to what extent technology is used, teachers were asked to self-assess their use of technology and related pedagogy through the lens of SAMR and TPACK, researched based technology-integrated education models. And finally, teachers were given the opportunity to respond to open-ended questions to capture more detail regarding the program's strengths and weaknesses as well as what future professional development could better support them in effectively integrating technology into their classrooms.

Table 2

Survey Data Alignment to Study Purpose and Research Questions

Research question	Data type	Purpose
RQ1. What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment?	Quantitative Likert scale	Collect teachers' perceptions of the effectiveness of one-to-one technology and related professional development.

Research question	Data type	Purpose
RQ2. How often and to what extent is one-to-one technology integrated into instruction?	Quantitative Likert scale	Collect teacher-reported use of technology-integrated instruction and knowledge as defined by the SAMR and TPACK models.
RQ3. What are the strengths and weaknesses of technology integrated teaching and learning?	Qualitative open-ended responses	Collect specific teacher input regarding the benefits and challenges of the 1:1 initiative not captured in the close-ended Likert scale survey questions. *Triangulate with RQ1 data*.
RQ4. What professional development is needed to support technology integrated instruction?	Qualitative open-ended response	Collect teacher input regarding professional development that would help improve technology-integrated instruction. *Triangulate with RQ1 data*.

Setting & Participants

The Wattsburg Area School District is in a rural northwestern Pennsylvania setting with four townships: Amity, Greene, Greenfield, Venango, and the borough of Wattsburg, covering 144 square miles. The District is primarily a bedroom community for nearby Erie, Pennsylvania with very few businesses and is the top employer with approximately 200 employees. The top tax revenue generating businesses are Lake Erie Speedway and Auto Express. Community resources include a YMCA daycare operated in Wattsburg Area Elementary Center, four hospitals within a 45-minute drive, and access to five colleges. The National Center for Educational Statistics (2021) reports the total population of the District to be 10,286, consisting of 3,923 households with a median household income of $69,194. The racial and ethnic composition of the District population is very homogeneous with 97% white, 1% Hispanic or Latino, 1% Asian, and 3% other.

Students

There are three schools in the District that serve approximately 1,300 students. Wattsburg Area Elementary Center (WAEC) enrolls about 450 in Grades K-4, Wattsburg Area Middle School (WAMS) enrolls about 400 in Grades 5-8, and Seneca High School (SHS) enrolls about 430 in Grades 9-12. The student gender distribution is shown in Table 3. The racial and ethnic composition of the students mirror that of the District population as a whole and is depicted in Table 4.

Table 3

WASD Student Gender Distribution

	WAEC	WAMS	SHS	Total	%
Male	232	200	245	677	52.0%
Female	237	203	184	624	48.0%

Table 4

WASD Student Racial and Ethnic Composition

	WAEC	WAMS	SHS	Total	%
White	452	375	405	1232	94.7%
Hispanic	9	12	10	31	2.4%
Multi-racial	5	14	9	28	2.2%
Black	2	2	3	7	0.5%
Asian	1	0	1	2	0.2%
Indian	0	0	1	1	0.1%
Total	469	403	429	1301	100.0%

The District serves regular education students, gifted students, and special education students. Gifted students are provided enriched instruction at the elementary center and the middle school. Gifted students at the high school are served by enrolling in Advanced Placement classes with some gifted students taking college classes through dual enrollment courses, which are available to regular students as well. Fifteen percent of the high school students receive vocational training through the Erie County Technical School, for which they attend half-days. The high school also operates an Air Force ROTC program which enrolls students from two adjacent school districts in addition to its own.

All three WASD schools have a dedicated special education staff that deliver a full range of supports from full-time to itinerant services. The elementary school houses an early intervention preschool program operated by the Northwest Tri-County Intermediate Unit serving students from adjacent districts in Erie County. There is an Autistic Support program at the high school. There are Life Skills Support programs for students in kindergarten through age 21 at the high school and elementary school serving students from around Erie County. In addition, each building has an emotional support program. The enrollment of students in the District's special education program constitutes 20.4% of the student body as compared to 18.1% for all students in the state of Pennsylvania (Pennsylvania Department of Education, 2021b). The rate of economically disadvantaged students is consistently between 32-34%.

Faculty

There are 102 WASD faculty members consisting of 22 men and 80 women.

The faculty is predominantly White with only one Black and one Hispanic faculty member. Age ranges for the faculty are shown in Figure 10. Most of the faculty are clustered in the 30-35 and over 50 age groups. Faculty education levels and additional graduate credits are depicted in Figure 11. About half of the faculty hold master's degrees and approximately a third hold only a bachelor's degree.

Figure 10

Faculty Age Ranges

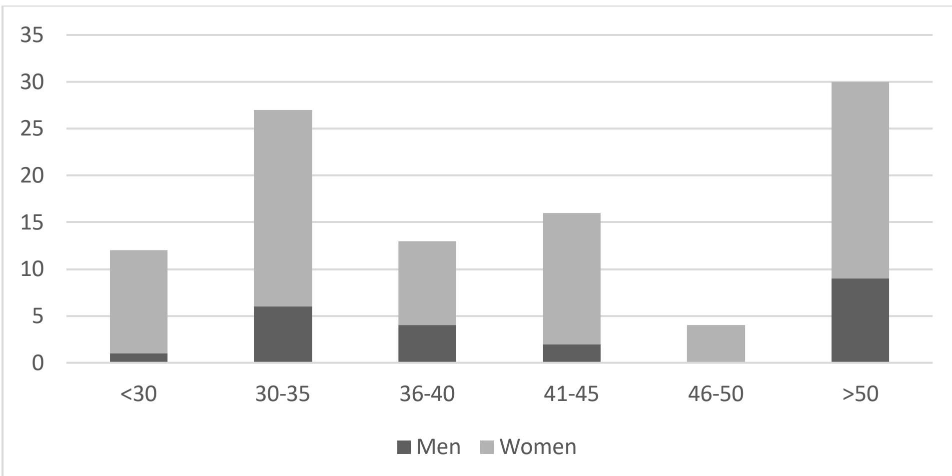
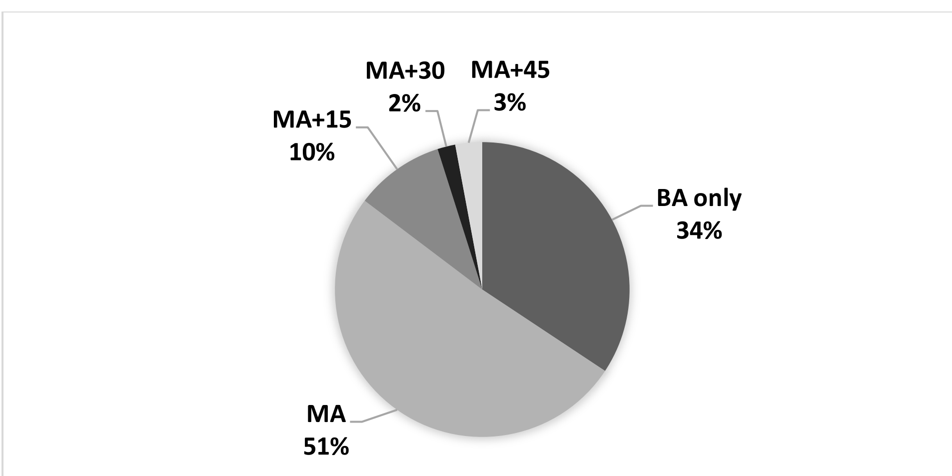


Figure 11

Faculty Education Levels and Graduate Credits



Student and Faculty Technology

The WASD 1:1 program utilizes a variety of technology. The primary device for each student is a compact HP ProBook x360 11 G5 with touch sensitive screen for students in Grades 3-12. The primary device for students in Grades K-2 is a Microsoft Surface Go tablet with a touch sensitive screen, which is preferred by the teachers for this student age range. The primary device for all faculty is a Microsoft Surface Book 3 with a 13" touch sensitive screen. All primary devices are Wi-Fi enabled and on 3-year lease cycles. In addition, all teacher classrooms are outfitted with Epson Interactive projectors which enable the teachers to use their white board or wall as an interactive whiteboard and can be projected to wirelessly from their Surface Book. Depending on the grade level and subject area, various other secondary technology devices are used such as Elmo projectors, 3-D printers, and a variety of USB scientific probes. During program implementation, the District's Wi-Fi network and internet capacity was increased significantly for the 1:1 program to support the use of almost 1,600 computers that utilize these resources at any given time during the school day with average download speeds consistently over 100 Mbps.

Informed Consent

All faculty members were invited to participate in the voluntary 1:1 technology initiative survey via email containing the informed consent letter (see Appendix A for 1:1 technology initiative survey consent) that was approved by the Institutional Review Board (IRB) of California University of Pennsylvania (see Appendix B for IRB approval). In addition, all participants were required to read the informed consent conditions again when they clicked the hyperlink in the invitation email to start the survey. The informed consent information at the beginning of the survey states that completing the survey indicates their consent to participate and have their data used in the study (see Appendix C for 1:1 technology survey). The Wattsburg Area School District Board of Directors also approved this research (see Appendix D for WASD research approval).

Research Plan

The most predominant theme in the literature is that effectively integrating 1:1 computing into teaching and learning is multifaceted and involves not only changes to physical infrastructure and technical support, but also systemic changes to teaching practice (Lamb & Weiner, 2021). The literature indicates that when teachers do not receive adequate professional development (PD) when implementing a 1:1 computing program, many obstacles to instruction can occur (Bebell & Kay, 2010). The literature is also clear that professional development practices must be systematic to bring about change (Curry et al., 2019; Keane & Keane, 2017; Ross, 2020). And research suggests that how teachers *perceive* technology can impede integration into instruction (Kampookaew, 2020). Therefore, this research plan includes researcher generated close ended survey questions designed to collect quantitative data that would indicate the teachers' general perception of the 1:1 initiative's effectiveness including the related professional development. The perception effectiveness prompts ask teachers to respond on a 5-point bipolar Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Perception question examples are listed in Table 5. In addition to collecting demographic information, the research plan includes having participants identify their primary grade level, K-6 or 7-12, and their primary subject area to allow for comparison of the data between grade levels and subject areas taught using bar graphs, descriptive statistics, and *t*-tests. The special subject teachers are all grouped into a K-12 group because their certifications run K-12, and many special teachers teach across the primary and secondary levels in the District encompassing a wide variety of specialty subjects. Therefore, their responses are analyzed and presented, but not to the extent of the comparison between the K-6 and 7-12 core teacher subgroups. Finally, an open-ended question is included in the research plan to gather qualitative teacher feedback regarding professional development needs in addition to the Likert scale data.

Table 5

Effectiveness Perception Question Examples

Perception of	Question
1:1	Students use technology in my classroom for learning every day.
1:1	During lessons that involve PC use, student engagement is high.
1:1	Student learning is enhanced by PC devices in my classroom.
PD	The professional development I received on teaching in a 1:1 PC environment was effective.
PD	The Technology Integrators are an effective support or resource.
PD	I utilize the Technology Integrators regularly.

WASD's six-year buildout of physical infrastructure, device selection, internet capacity, and technical support was well planned and has resulted in a robust system that operates smoothly with little to no disruption according to anecdotal accounts from the faculty and technology department staff. This is consistent with the best practices identified in the physical infrastructure portion of the literature review (Curry et al., 2019; Keane & Keane, 2017; Lamb & Weiner, 2021; Vu et al., 2019). Two open-ended questions are included in the research plan to collect qualitative teacher feedback. One question to examine strengths and weaknesses, and a second to detect any potential obstacles presented by the physical infrastructure or other barriers impeding the program's effectiveness.

1:1 Program Evaluation

The primary focus of this action research project is to evaluate the effectiveness of WASD's 1:1 program. Research suggests that using student achievement data to evaluate the effectiveness of technology integrated environments produces mixed results, especially between subjects (Curry et al., 2019). The literature also indicates that 1:1 program evaluation should be comprehensive, looking beyond grades and standardized achievement scores. Another theme in the literature is that the reason for implementing a 1:1 program is to change the way students learn and teachers teach. Desired outcomes often include personalized learning, increased student engagement, and collaboration (Cole & Sauers, 2018). Finally, research done into program evaluation suggests that 1:1 programs should be evaluated holistically from the perspective of professional development and program goals (Morrison et al., 2019).

Consistent with the literature, this research plan makes use of two researched based models for comprehensively examining technology integrated instruction: SAMR and TPACK (Puentedura, 2010; Schmidt et al., 2009). The SAMR model focuses on how teachers teach with technology whereas the TPACK model focuses on the types of knowledge teachers require for integrating technology into instruction. The SAMR model section of the survey asks teachers to self-assess their use of the Substitution, Augmentation, Modification, and Redefinition levels of instruction on a 5-point unipolar frequency Likert scale ranging from 1 (never) to 5 (always). The TPACK section of the of the survey is lengthier, prompting teachers with a series of 5-point bipolar Likert scale items ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) related to each technology related TPACK domain:

- Technology Knowledge (TK)
- Technological Content Knowledge (TCK)
- Technological Pedagogical Knowledge (TPK)
- Technological Pedagogical Content Knowledge (TPACK)

Research Design, Methods & Data Collection

This is an action research project (Quan + qual, convergent parallel design) utilizing a voluntary staff survey to collect data related to the research questions and data classification. The project, including the survey instrument (see Appendix C for 1:1 technology survey), was approved by the IRB of California University of Pennsylvania (see Appendix B for IRB approval). This study is mixed method, analyzing quantitative survey data using bar graphs, descriptive statistics, and two-tailed independent samples *t*-tests to determine if survey response data reveals statistically significant differences in response patterns between the primary grades (K-6) and the secondary level (7-12). Qualitative data in the form of three open-ended questions were also collected and analyzed via coding. All survey data were collected from participating teachers via a secure online form (Microsoft Forms) in faculty meetings held in each school building on Wednesday, February 9, 2022. The survey was set to only accept one response from each participant to prevent duplicate data. Prior to the administration of the voluntary 1:1 technology initiative survey, the researcher met with each faculty group and provided a brief presentation to explain the action research project and provide an overview of the survey's construction, including a discussion of the SAMR and TPACK models of technology-integrated instruction to ensure the faculty understood those concepts (see Appendix E for technology survey faculty presentation). The online survey link was sent to all 102 faculty members via email and teachers were asked to complete it after the faculty presentations. Participation in the survey included 74 or 72.5% of the faculty.

Research Question One

What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment? Quantitative data to address Research Question One were gathered by the survey in two parts using 5-point bipolar Likert scales (see Appendix C for 1:1 technology survey). One, the teachers' general perceptions of teaching in a 1:1 environment such as the frequency of computer use in the classroom, student engagement levels, and the effectiveness of computers in teaching and learning as applied to their subject and grade level. And two, the teachers' perceptions of professional development aligned with key findings of the literature review. For example, effective professional development identified in the literature includes Professional Learning Communities, Professional Learning Networks, Train-the-Trainer, and Coaching (Cook et al., 2017; Love et al., 2020). The WASD 1:1 initiative utilized all these approaches to technology professional development to varying degrees during implementation. Early in the initiative, a full time Technology Coach position was created to assist teachers in the District's elementary, middle, and high school. Early feedback from the faculty indicated this model of professional development was not broadly accessible when needed and the administration felt that it was not an effective use of resources. As a result, the technology coach position was eliminated and six Technology Integrator positions, two in each building, were created to create a Professional Learning Community, provide Coaching, and facilitate Train-the-Trainer sessions. Research Question One produced data to evaluate the effectiveness of this professional development structure.

Research Question Two

How often and to what extent is 1:1 technology integrated into instruction? Data to address Research Question Two were also gathered by the survey in two parts using 5-point bipolar Likert scales reflecting research-based models for technology-integrated instruction (see Appendix C for 1:1 technology survey). The first part utilized the SAMR model to assess how often technology-integrated instruction utilizes Substitution, Augmentation, Modification, and Redefinition as described in the literature via a unipolar frequency Likert scale (Puentedura, 2006; Puentedura, 2010; Puentedura, 2013). The second part utilized the TPACK model to assess the teachers' level of knowledge in the technology-specific related domains of the model as described in the literature (Eutsler, 2020; Schmidt et al., 2009). The 5-point bipolar Likert scale questions for this section of survey were adapted with permission from a study by the original researchers of the model, Schmidt et al., 2009, referenced in the literature review (see Appendix F for TPACK survey use permission). The assessed areas from the TPACK model included Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and finally all the components collectively, Technology, Pedagogy, and Content Knowledge (TPACK).

Research Question Three

What are the strengths and weaknesses of technology integrated teaching and learning? Qualitative data to address Research Question Three were gathered via two open-ended response questions in the survey:

1. What do you feel are the benefits of every student having a PC device?
2. What are the challenges to integrating technology into teaching and learning?

The literature review revealed many issues that can impact the effectiveness of 1:1 programs such as physical infrastructure, device selection, cost, and technical support (Khlaif, 2018; Lamb & Weiner, 2021; Vu et al., 2019). As such, these open-ended questions were crafted to allow the teachers to confirm effective practices, reveal weaknesses, and expose other needs or issues that will be used to help improve technology-integrated instruction.

Research Question Four

What professional development is needed to support technology integrated instruction? Qualitative data to address Research Question Four were gathered via one open-ended response question in the survey: What professional development is needed to support technology integrated instruction? The literature review showed that professional development plays a critical role in supporting teachers to effectively integrate 1:1 technology into instruction (Bebell & Kay, 2010; Curry et al., 2019; Keane & Keane, 2017; Lamb & Weiner, 2021; Ross, 2020). This open-ended question was included to gather teacher feedback on what professional development would best support them moving forward in a 1:1 technology integrated environment.

Fiscal Implications

The annual 1:1 program budget is approximately $700,000 representing almost 3% of WASD's $25 million budget. It is a significant investment. The results of this study will be used to determine if the expense is justified or if the 1:1 budget could be restructured to achieve better results. For example, if the results reveal that the general effectiveness of 1:1 at the K-6 level is significantly less than at the 7-12 level, additional research will need to be conducted to reveal possible reasons. From there, modifications can be made in areas such as device selection, technical support, professional development topics, and structure, infrastructure improvements, etc. Any program changes of this nature could necessitate budget adjustments. However, the fiscal impact may not increase the bottom line if efficiencies or other budget neutral modifications are made.

Validity

The survey instrument used in this study utilizes content validity derived from two primary sources. The first source of content validity was obtained by piloting the survey with several of the District's highly trained Technology Integrators (teachers) that are subject matter experts. The integrators were asked to provide written feedback regarding question construction, technology content, and overall impression of the instrument. The integrators' feedback included recommendations that were incorporated into the survey such as:

- On page three of the survey, it would be helpful to have the SAMR model figure displayed below the description.
- SAMR section: All the descriptions are informative and will help participants in filling out the form. Easy to understand and could be filled out by anyone, even those who may not have a lot of background or knowledge in integrating technology.

- Under the TPAK (Technology Knowledge) section, question 4 reads "I frequently play around the technology." Suggest change to "play around with new technology."

Several other teachers were asked to pilot the survey to confirm face validity. That is, did the respondents think the survey questions measure what they are intended to measure? Feedback from these respondents included incorporated recommendations such as:

- I did struggle with the following question, "The 1:1 PC device initiative is effective for my subject area," because I teach two subjects. As we talked about, technology doesn't lend itself to math very well, but it is terrific with science. I feel that you might not get the data you are looking for unless you break it down to a question for Elementary (K-6) and secondary (7-12) or in some other way for those that teach multiple subjects.
- I felt that your SAMR treatment was well done and very easy to understand. I don't know if I feel the same way about your TPACK approach. I feel like a little more definition would help me understand what was happening there. I understood each of the questions. That was great, but I am unfamiliar with TPACK and feel that I now need a lesson on what that strategy is all about.
- Open-ended question: "Please reflect on the 1:1 student computer initiative and how increased access and use of technology for teaching and learning has impacted your classroom. *Suggest edit to this:* "Please reflect on the 1:1 student computer initiative. Think about how the increased access and use of technology for teaching and learning has impacted your classroom."

TPACK Survey

The second primary source of content validity is unique to the TPACK survey questions. In 2009, Iowa State University and Michigan State University collaborated to produce a reliable survey instrument to assess the understanding of TPACK in preservice teacher education (Schmidt et al., 2009). The researcher received consent from Schmidt to use the research team's questions from the survey for this action research project (see Appendix E for technology survey presentation). Schmidt et al. (2009) explains that "the research team used quantitative research methods to establish the extent of the validity and reliability of the instrument" (p. 130). The research team then assessed each TPACK knowledge domain subscale for internal consistency using Cronbach's alpha reliability technique. The researchers concluded that the high internal consistency indicates that the survey instrument is a reliable measure of TPACK and its knowledge domains (Schmidt et al., 2009). Table 6 shows the TPACK survey sections used in this study and their internal consistency.

Table 6

Reliability of TPACK Survey Scores

TPACK Domain	Internal Consistency (alpha)
Technology Knowledge (TK)	.86
Technological Content Knowledge (TCK)	.86
Technological Pedagogical Knowledge (TPK)	.93
Technological Pedagogical Content Knowledge (TPACK)	.89

Likert Scale Data

Most data in this study were collected via bipolar Likert scales except for the SAMR data, which utilized a unipolar Likert scale. The first portion of this study consists of an overview of the teachers' perceptions of the effectiveness of the 1:1 computer initiative at the K-6 and 7-12 levels summarizing Likert scale data collected via a faculty survey. The initial face value data presentation of Likert scale data is displayed in response-percentage bar graphs as it is not appropriate to use parametric statistics on individual Likert scale item data, which produces ordinal level or nonparametric data (Sullivan & Artino, 2013). However, both the teacher perception and TPACK Likert scale survey sections measure different constructs in terms of how teachers perceive the effectiveness of technology-integrated instruction, professional development, and their self-assessment of TPACK defined skills. A construct is a psychological term used to describe unquantifiable and complex human behavior that is not easily assessed by a single question. Therefore, these sections of the survey instrument feature multiple related questions grouped around each construct. In this way, a participant average score can be derived from each construct section thereby converting it to interval scale data that can then be analyzed using a variety of parametric statistics (Bertram, 2006; Sullivan & Artino, 2013). For example, the mean and standard deviation was calculated for all the participants' category scores to the Likert scale sections assessing their perception of the effectiveness of the 1:1 initiative and related professional development. The SAMR unipolar frequency Likert response items were singular (not scalable), so the resulting nonparametric data is only reported and analyzed as response-percentage bar graphs.

Likert Scale Direction

The direction of the Likert scales used in this research was selected to obtain the most valid data. Research indicates that disagree-to-agree scales generally produce poorer data. Salzberger and Koller (2019) explain that disagree-to-agree formats add additional cognitive burden because respondents are occupied with handling the response scale instead of fully concentrating on the survey content. Accordingly, this survey uses the following agree-to-disagree format Likert scales:

- Bipolar: Strongly Agree, Agree, Neither Agree or Disagree, Disagree, Strongly Disagree
- Unipolar: Always, Often, Sometimes, Rarely, Never

Mann-Whitney U Versus t-test

There is a general long-standing controversy in the literature when it comes to the analysis of Likert scale data. Specifically, can ordinal data converted to numbers like that produced by Likert scales be analyzed using parametric statistics (Sullivan & Artino, 2013)? For example, some experts contend that parametric tests such as the *t*-test should not be used on ordinal or nonparametric data. Instead, non-parametric tests such as the Mann-Whitney U should be used. However, more recent research indicates that not only can parametric statistics be used to analyze ordinal data, but they are also generally more robust and provide acceptably accurate and unbiased answers, even with skewed distributions and small sample sizes (De Winter & Dodou, 2010; Sullivan & Artino, 2013). Norman (2010) conducted a robust study into the use of parametric statistics with Likert data and concluded:

> Parametric statistics can be used with Likert data, with small sample sizes, with unequal variances, and with non-normal distributions, with no fear of "coming to the wrong conclusion." These findings are consistent with empirical literature dating back nearly 80 years. (p. 631)

Thus, this action research project utilizes two-tailed independent samples *t*-tests to investigate if there are statistically significant differences in response patterns from core subject and special education teachers between the primary grades (K-6) and the secondary level (7-12).

Triangulation

Triangulation compares information to determine corroboration; in other words, it is a process of qualitative cross-validation (Wiersma 2000 as cited in Oliver-Hoyo & Allen, 2006). For example, the open-ended professional development prompt related to Research Question Three generated responses that were coded and organized into themes. These themes were then compared with the professional development Likert scale data collected for Research Question One to look for convergence or divergence between the two sources of data to enhance validity through triangulation, an advantage of the convergent parallel study design. This process was applied to the other open-ended question responses and corresponding Qualitative Likert data.

Summary

The purpose of this Capstone Research Project is to examine the efficacy of WASD's 1:1 technology initiative. It is an action research project utilizing a Quan + qual, convergent parallel design. All data for this study were collected utilizing a voluntary staff survey related to the research questions:

1. What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment?
2. How often and to what extent is 1:1 technology integrated into instruction?
3. What are the strengths and weaknesses of technology integrated teaching and learning?
4. What professional development is needed to support technology integrated instruction?

The research plan was developed from primary findings in the literature review regarding 1:1 technology-integrated instruction. The literature indicates that teacher perception, professional development, and how teachers use technology for instruction (pedagogy) are all critical pieces of an effective 1:1 instructional environment. As a result, the 1:1 staff technology survey instrument was designed to gather data about these three key areas using 5-point Likert scale items and several open-ended questions. The survey items related to technology pedagogy were developed from the researched based SAMR and TPACK models of technology-integrated instruction. Additional research was conducted while creating the staff 1:1 technology survey instrument into effective Likert scale survey item construction and acceptable statistical methods to analyze Likert scale data.

The survey instrument used in this study employs both content and face validity obtained by piloting the survey to content experts and faculty members and incorporating their feedback. In addition, the TPACK Likert scale survey items were obtained and used with permission from the original researchers of this model (Schmidt et al., 2009), who vetted the validity of the survey's internal consistency using Cronbach's alpha reliability technique. The convergent parallel design allowed for triangulation between quantitative Likert data and corresponding open-ended question response data to further enhance validity. Finally, the results of this study will be used to improve WASD's 1:1 technology program, which may involve modifications such as device selection, technical support, and professional development, all of which could have fiscal implications.

CHAPTER IV

Data Analysis and Results

The data collected for this Doctoral Capstone Project were captured using an online faculty survey via Microsoft Forms. The survey collected data in five primary areas: faculty demographics, teachers' perceptions of the effectiveness of the 1:1 technology initiative and related professional development, teachers' self-reported use of technology as per the SAMR levels of instruction, teachers' self-reported knowledge in terms of the TPACK framework, and open-ended questions designed to collect teacher-specific feedback on the strengths and weaknesses of the 1:1 program as well as input on future professional development. The data analysis process is explained in this chapter along with a presentation and discussion of the results.

Data Analysis

A link to the 1:1 Technology Survey was sent via email to 102 faculty members of the WASD on Wednesday, February 9, 2022. After the survey was administered, the researcher downloaded the raw survey data from Microsoft Forms to an Excel Spreadsheet. To start the process, multiple copies of the original Excel file were made. The filter and sort functions of Excel were then used to divide and organize the quantitative survey data in preparation to analyze it and address each research question. For example, a copy of the survey Excel file was created and titled *Perception by Groups Individual Likert Items* to address parts of Research Question One. The data in this Excel workbook was sorted by grade level and primary teaching assignment. Additional worksheets were created in the workbook and labeled to contain response data sorted and filtered by grade levels: K-6, 7-12, and K-12 Specials. Once the grade level worksheets were populated with the appropriate survey response data, Excel *Pivot Tables* were used to create tables in new worksheets arranged by grade level group and Likert response counts for each survey perception question associated with Research Question One as shown in Table 7. From there, each response count table was highlighted, and the *Insert Column or Bar Chart* function of Excel was selected to generate bar graph figures for each of the individual survey perception questions such as "students use technology in my classroom for learning every day." This general process was duplicated as needed to create a variety of tables and figures to analyze the quantitative survey data.

Table 7

Response Count Table Organized by Group

Students use technology in my classroom for learning every day.					
Group	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
K-12 Specials	7	5	2	3	1
7-12	5	16	4	8	1
K-6	10	10	1	1	0

Note. The K-6 and 7-12 groups include special education and Title teachers.

The *Analysis ToolPak* add-in was loaded into Excel using instructions obtained from the Microsoft Office website (Microsoft, 2022). The Analysis ToolPack allowed for parametric and nonparametric statistical analysis of the survey data. The ToolPak was used to calculate descriptive statistics such as mean and standard deviation for some sets and subsets of the Likert response data where statistically appropriate. To complete this, Likert scale responses were converted to scores on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) using the Excel *Find and Replace* function. The numerical data were sorted, copied, and pasted into new worksheets accordingly. For instance, multiple item Likert scores related to a construct such as "1:1 technology is effective" were averaged together yielding a single scaled score for the construct for each participant as shown in Table 8. All the participants' scaled scores for this construct were then placed into spreadsheet columns arranged by grade levels: K-6, 7-12, and K-12 Specials. The data in each column were subsequently highlighted and the *Data Analysis* tab under the *Data* menu was selected activating the *Analysis Tools* menu. The *Descriptive Statistics* option was then selected to calculate the mean and standard deviation for each grade level group. A very similar process was used to assess if there were significant differences in the overall perception of the effectiveness of the 1:1 program, related professional development, and TPACK domain area knowledge between the primary (K-6) and secondary (7-12) levels. This assessment was accomplished by calculating *t*-tests between the K-6 and 7-12 core subject and special education teacher groups using the Excel Analysis ToolPak.

Table 8

Participant Likert Scaled Score Calculation

Construct – 1:1 technology is effective.	Score
Students use technology in my classroom for learning every day.	4.00
During lessons that involve student PC use, student engagement is high.	3.00
Student learning is enhanced by PC devices in my classroom.	4.00
The 1:1 PC device initiative is effective for my grade level.	4.00
Likert scaled score	$M = 3.75$

Note. The Likert scaled score is the mean of the individual participant responses to multiple Likert items arranged around a construct.

The qualitative survey data were analyzed using a top-down deductive coding process often used in program evaluation research (Yee, 2022). The process involved creating a coding table closely related to the research questions and key findings of the literature review regarding the effectiveness of 1:1 technology programs. For example, the first open-ended question related to Research Question Three asks, "What do you feel are the benefits of every student having a PC device?" The research cites many benefits of 1:1 technology such as ease of access to technology and information, differentiation of instruction, improved student-teacher communications, and increased student engagement (Bebell & Kay, 2010; Warschauer, 2008; Zheng et al., 2016). As per Yee (2022), an initial coding list was created from these key findings and an initial coding session for open-ended responses from question one was conducted and organized using an Excel spreadsheet. At the end of the analysis, several other teacher-identified advantages were identified resulting in a modified code list such as making it easier for students that are absent to complete missed schoolwork and preparing students for the technology workplace. Each participant response received up to two codes. Codes that received less than three matches were treated as outliers and discarded. The process was repeated for the other open-ended questions related to Research Question Three and Four to create the final codebook (see Appendix G for qualitative data codebook). Once all the qualitative data were coded in an Excel spreadsheet, the data and coding for each question was moved to individual worksheets within the workbook. This allowed for sorting of the data by question and code to create figures with Excel's chart functions and look for prominent themes to accompany the presentation and discussion of the results for illustrative and triangulation purposes.

Results and Discussion

The survey was completed by 74 or 72.5% of the 102-member faculty. There were 52 female respondents, 20 male respondents, and 2 respondents of unspecified gender. Similar to the faculty demographics as a whole, the two largest age groups among participants were those 30-35 with 20 participants, and older than 50 with 19 participants which collectively accounts for 54% of respondents. Faculty representation was very good at SHS and WAMS with nearly 100% participation. WAEC representation was smaller with approximately a third of the K-4 staff participating.

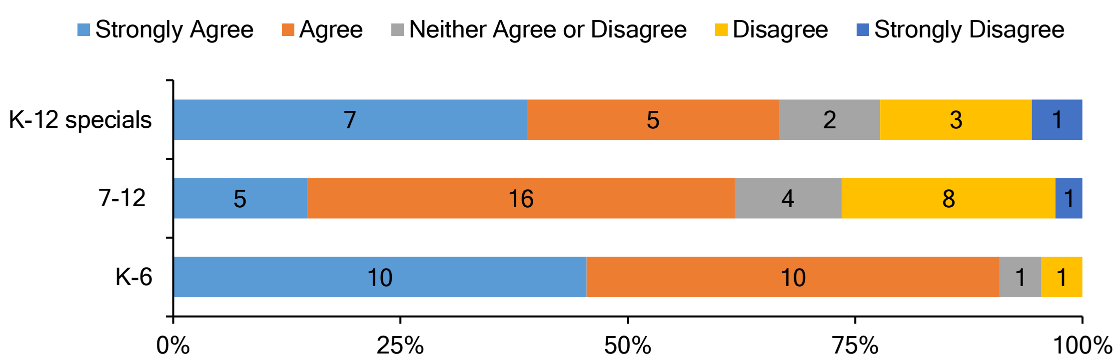
Effectiveness of 1:1 Technology

Research Question One asks, "What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment?" Data to address Research Question One were collected in the first part of the 1:1 technology survey in two parts (see Appendix C for 1:1 technology survey). The first part of the survey presented teachers five Likert items about their perception of the effectiveness of 1:1 technology. The second part presented teachers with four Likert items about their perception of the effectiveness of related technology professional development. For the first part, perception of the effectiveness of 1:1 technology, the results for four of the five Likert items are shown in Figures 12-15. Data from all 74 participants are captured in these figures. One of the five Likert items in this section of the survey asked participants to rate the effectiveness of 1:1 technology for *their subject area*. Because the literature review discusses the effect of 1:1 technology on three specific core subject areas, the results from ELA, math, and science teachers were broken out for individual analysis in Figures 16-18 respectively. These results represent subsets of study participants by subject area.

Figure 12 shows that use of technology is high across grade levels and subjects. The K-6 level is the highest with 90% of the participants confirming daily technology use. The 7-12 and K-12 specials also indicate high daily use of at least 62% or more. These results are consistent with a prominent theme in the coded qualitative data regarding the benefits of every student having a PC device. Participant 6 wrote, "Every student having a PC device and reliable internet has completely changed how I run my classroom. With ease, I can ask students to work with technology and combine this with paper/pencil or more traditional instruction." Participant 57 wrote, "The ability to use technology at any moment without having to rely on schedules or sharing of devices."

Figure 12

Students Use Technology in My Classroom for Learning Every Day.

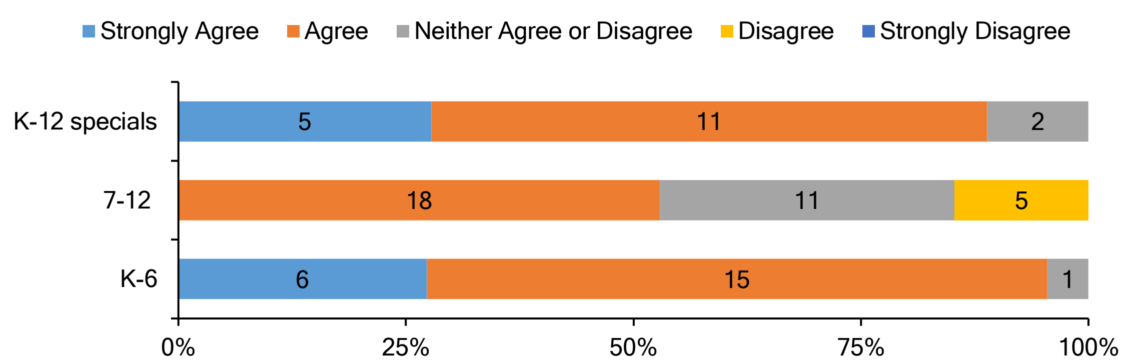


Note. The numbers inside the colored bars are the number of teacher responses.

The K-6 teachers reported the highest combined Strongly Agree and Agree student engagement rating when lessons involve PC use of 95% followed by the K-12 specials teachers at 88% as shown in Figure 13. Only about 53% of the high school teachers agreed that student engagement is high when using technology. The qualitative data collected for Research Question Three (strengths and weaknesses of 1:1 technology) did not reveal any generalized reasons for the relatively low agreement level among the 7-12 participants, although there were several participants that noted challenges with 1:1 technology. For example, participant 52 wrote that in can be difficult "making sure that students are staying on task, using computers appropriately, and not playing games or other things during a lesson." The level of teacher planning may also be a factor. There were only a few general statements about the benefit of student engagement such as "It greatly increases the level of engagement" (participant 41). The qualitative data also suggest low use by some specials such as art and gym. However, many of the specialty subjects like STEM, technology-education, and business class electives are courses that use technology frequently as a primary function of the subject material, which may account for the high level of student engagement reported by specialty subject teachers.

Figure 13

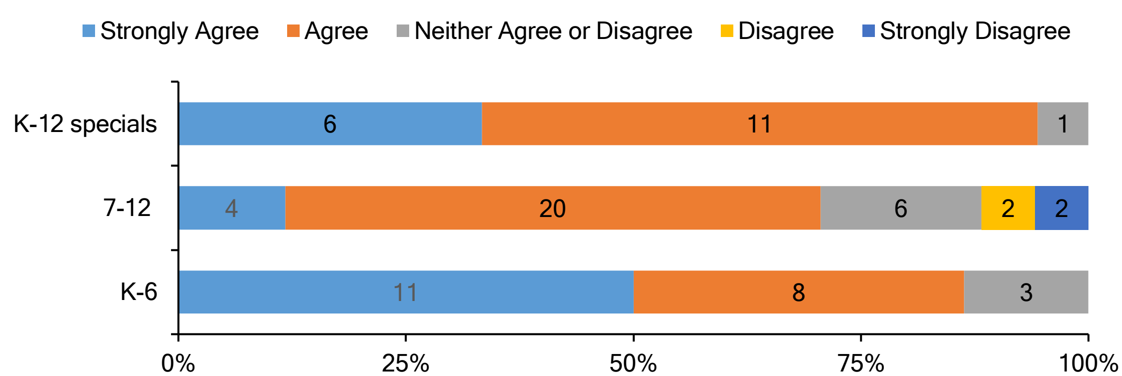
During Lessons That Involve PC Use, Student Engagement Is High.



There was a high-level of agreement across grade levels and subject areas that 1:1 technology enhances student learning as depicted in Figure 14. The K-12 specials combined Agree and Strongly Agree rating was 94%. The K-6 combined agreement level is 86% and the 7-12 combined agreement level is 71%. At the 7-12 level, this seems to contradict with the engagement level data i.e., enhancement is rated relatively high at 71% but reported engagement is rated at 53%, approximately 18% lower. Looking at the qualitative data collected for Research Question Three (strengths and weaknesses of 1:1 technology), many of the 7-12 faculty commented that the ease of access to technology and information has greatly increased because of the 1:1 program. Participant 1 wrote that a benefit of the 1:1 technology is, "Universal access to media, accessibility tools/assistive tech, opportunity for student choice/ownership over how they access material or display their knowledge." This sentiment among 7-12 faculty may account for the enhancement ratings being higher than the engagement ratings.

Figure 14

Student Learning Is Enhanced by PC Devices in My Classroom.

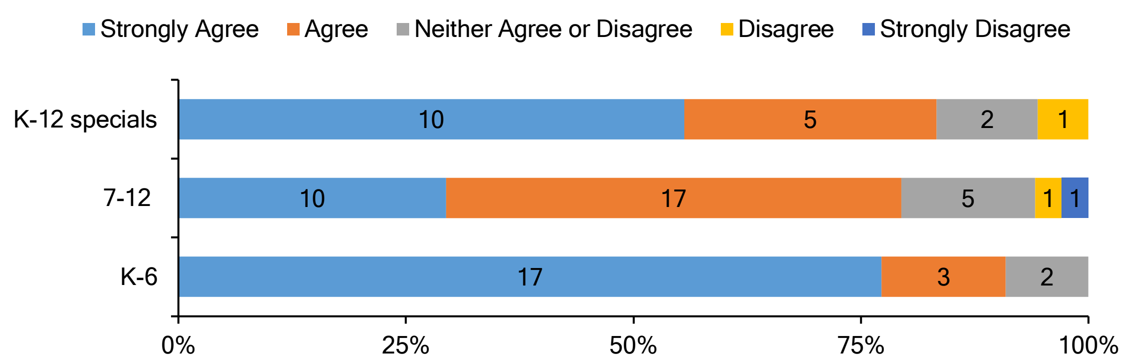


Grade Level and Course Subject Effectiveness

The survey item regarding the effectiveness of 1:1 technology at a specific grade level was presented to all 74 participants. Figure 15 shows that there is broad consensus among all participants that 1:1 technology is effective with combined Agree and Strongly Agree ratings all well above 75%. K-6 was the highest at 90% combined agreement, followed by K-12 specials at 83%, and 7-12 at 79%. This is corroborated by the three highest coded responses in the qualitative data considering the benefits of every student having a PC device: ease of access to technology and information, differentiation of instruction, and increased teaching options (Figure 19). The third highest coded rating, increased teaching options, is interesting as it is supported but not directly cited in the reviewed literature and is one of several codes that emerged from the qualitative data during the deductive coding process.

Figure 15

The 1:1 PC Device Initiative Is Effective for My Grade Level.

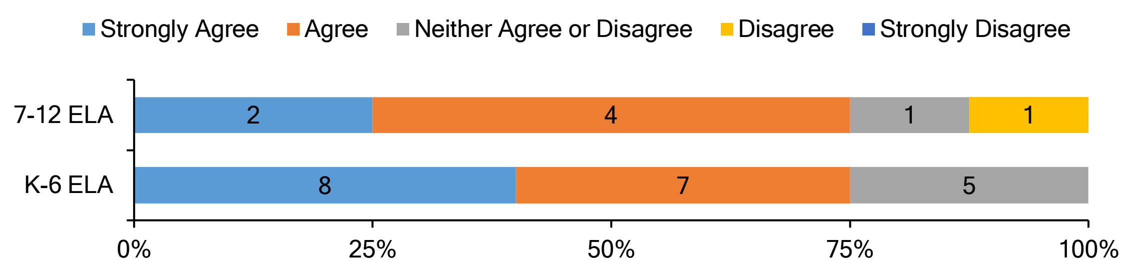


The sample size for the core subject breakout of ELA, math, and science 1:1 technology effectiveness are subsets of at least 25 participants in each area. However, the 7-12 subject area subsets are relatively small in comparison to the K-6 groups. Therefore, the 7-12 subject area subset data should not be taken at much more than face value and is generally considered together with the K-6 data in this analysis. Figure 16 shows that The K-12 ELA participants consider 1:1 technology to be very effective with a combined Agree and Strongly Agree rating of 75%. This is very consistent with the literature. Warschauer (2008) found that students with access to 1:1 technology used it at all stages of the writing and rewriting process and that it made review and feedback from the teacher much timelier. Similar benefits are cited in the qualitative data such as participant 24 who stated, “It is useful for modifying writing assignments and more engaging activities for students who become easily distracted.” Participant 60 noted:

> The students love creating their own content on the computer and are extremely proud of their work. Computer programs also offer immediate feedback. Teachers cannot offer immediate feedback to every student nearly as quickly, so this is a great benefit for them.

Figure 16

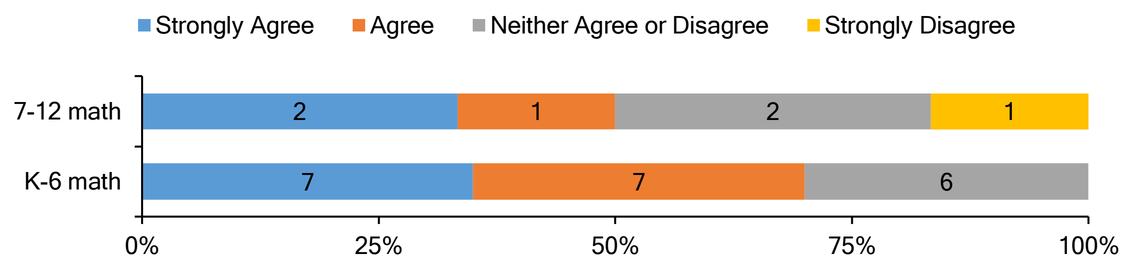
The 1:1 PC Device Initiative Is Effective for ELA.



The K-12 perception of the effectiveness of 1:1 technology for math was mixed as displayed in Figure 17 with the K-6 participants rating its somewhat higher than the 7-12 group. The qualitative data collected for Research Question Three regarding the challenges of 1:1 technology suggest that math does not readily lend itself to technology use, especially at the secondary level. For example, participant 10 wrote, "Math is difficult to integrate technology into. Using Study Island or Delta Math sometimes is difficult for students to show their work and therefore students do not always like to complete problems online." Participant 25 wrote, "It is difficult to use in the math world. In math there tends to have to be a lot of free handwriting which can be difficult to perform on the computer." This is consistent with the research that shows mixed results with the integration of technology and math instruction (Carr, 2012; Kiger et al., 2012). The K-6 math group had a more favorable view of math and 1:1 technology. This could be due to anecdotal principals' observations that there are several game-like math applications that Grades K-6 use frequently to reinforce primary math concepts and does not necessarily reflect the teachers' perception of instructional effectiveness.

Figure 17

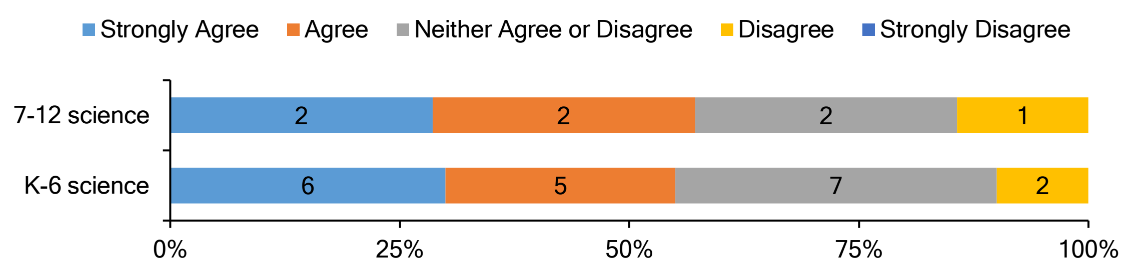
The 1:1 PC Device Initiative Is Effective for Math.



The K-12 perception of the effectiveness of 1:1 technology for science is consistent with a combined Agree and Strongly Agree rating of a littler more than 50% as indicated in Figure 18. The other half of the science participants were primarily indifferent towards technology and science.

Figure 18

The 1:1 PC Device Initiative Is Effective for Science.



There is sparse literature on the impact of 1:1 technology on science. One study indicated that integrated use of laptops in science classrooms can positively effect science standardized test scores (Dunleavy & Heinecke, 2007). Other studies of technology used in science instruction are very topic and application specific. For example, the use of Artificial Reality to study three dimensional items such as the solar system has been shown to improve student understanding of difficult spatial concepts (Kirikkaya & Basgül, 2019). It could be that WASD science teachers have not sufficiently explored science applications and related technology that can be used to effectively teach science. Or there may be other obstacles to obtaining such resources that account for the science teacher's divided perception.

Strengths And Weaknesses of 1:1 Technology

Research Question Three asks, "What are the strengths and weaknesses of technology integrated learning?" Qualitative data to address this question were collected via two open-ended survey questions (see Appendix C for 1:1 technology survey):

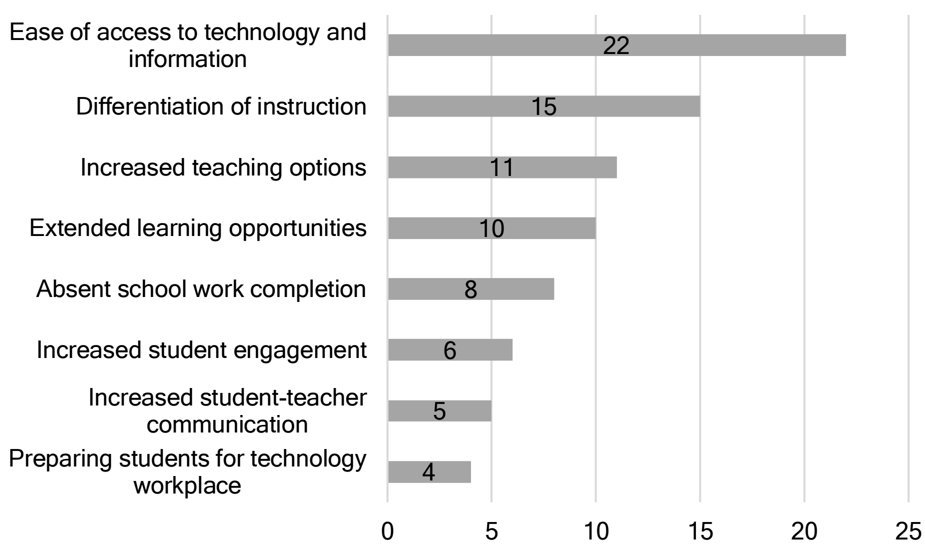
1. What do you feel are the benefits of every student having a PC device?
2. What are the challenges to integrating technology into teaching and learning?

Selected participant responses to these questions have been woven into the Likert quantitative results discussion for Research Question One for illustrative and triangulation purposes and warrant additional observations as they relate to the participants' overall perceptions of the benefits and challenges of 1:1 technology and key findings in the literature.

Qualitative findings of Michigan State University's meta-analysis (Zheng et al., 2016) suggest that 1:1 computing programs have a transformative influence on the entire educational environment such as "increased technology use for varied learning purposes; more student-centered, individualized, and project-based instruction; enhanced engagement and enthusiasm among students; and improved teacher-student and home-school relationships" (p. 1075). Zheng et al., also states "laptop computers have specific affordances that make certain uses and outcomes likely, such as the ease with which they can be used for drafting, revising, and sharing writing, and for personal access of information" (p. 1075). Figure 19 is a frequency bar graph summarizing participants' coded responses considering the benefits of every student having a PC device. Comparing the frequency of the coded responses in Figure 19 to the findings of Zheng et al., there is a high degree of corroboration. That is, the positive impacts of 1:1 student technology found in the literature were clearly validated by the faculty open-ended responses. In addition, triangulation is present between Research Question One and Three as the qualitative coded data in Figure 19 supports the overall positive quantitative Likert results outlined in Figures 12-16.

Figure 19

Benefits of Every Student Having a PC Device.



The coded responses about the challenges of teaching with technology revealed the top three issues to be time, technical problems, and integration with subject matter (Figure 20). These issues are clearly called out in the literature as being potential obstacles to effectively integrating 1:1 technology into instruction. Love et al. (2020)

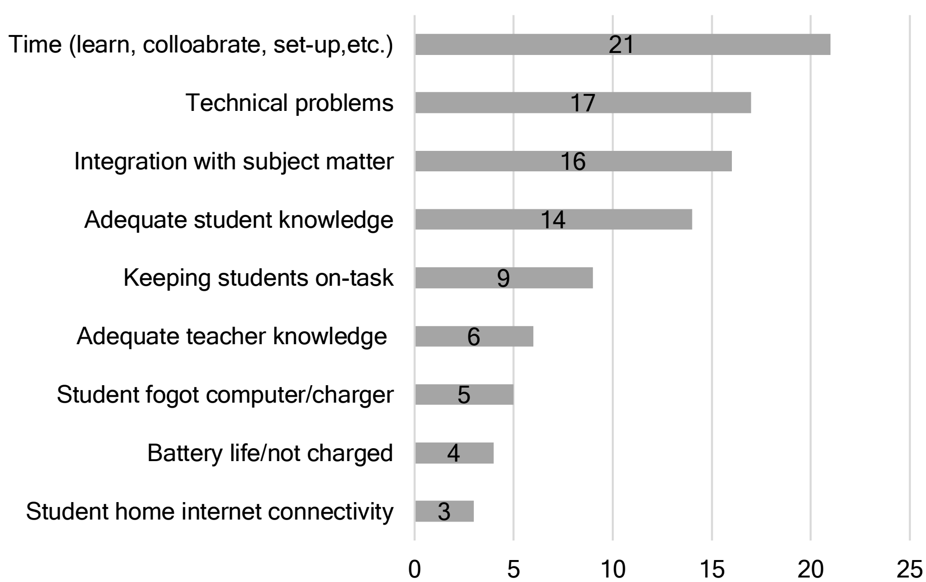
states that timely access to quality technical support must be a priority. Corey (2019) notes that teaching with technology involves complicated change which requires a significant investment in time for ongoing professional development. Application and collaboration opportunities are also important (Bebell & Kay, 2010; Darling-Hammond & Richardson, 2009). With regards to time and subject integration, participant 25 wrote:

> Not every subject is created equal when it comes to technology and how it is able to be used. It may take some teachers longer to understand it; therefore, the students in their classes may be behind than those students who are in classes with teachers who are more technologically advanced.

The quantitative and qualitative data about the effectiveness of 1:1 technology support its overall efficacy in enhancing the educational environment but also reveal that there are areas that present challenges to the staff than can be addressed to improve the program.

Figure 20

Challenges of Teaching with Technology.



Effectiveness of Technology Professional Development

The second part of Likert perception data collected to address Research Question One examined professional development related to 1:1 technology. Figure 21 shows that although most participants Agree or Strongly Agree that they have received 1:1 technology training, 28 participants or approximately 38% indicated they were indifferent or disagreed to some extent.

Figure 21

Received Professional Development on Teaching in a 1:1 Environment.

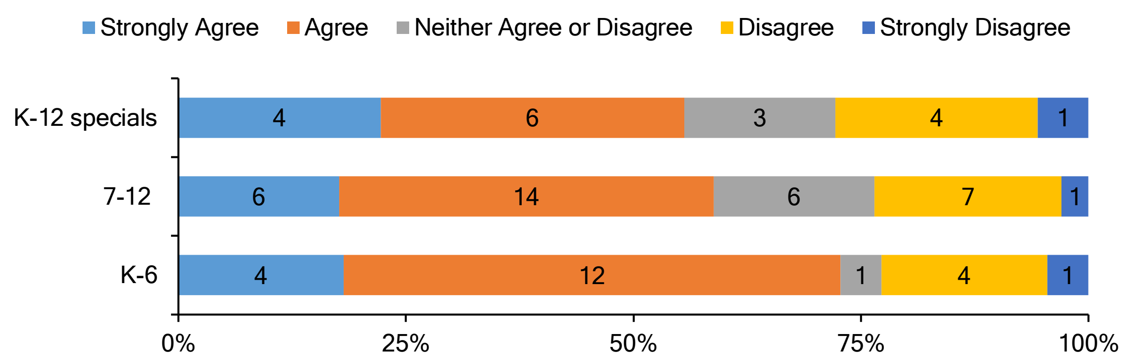
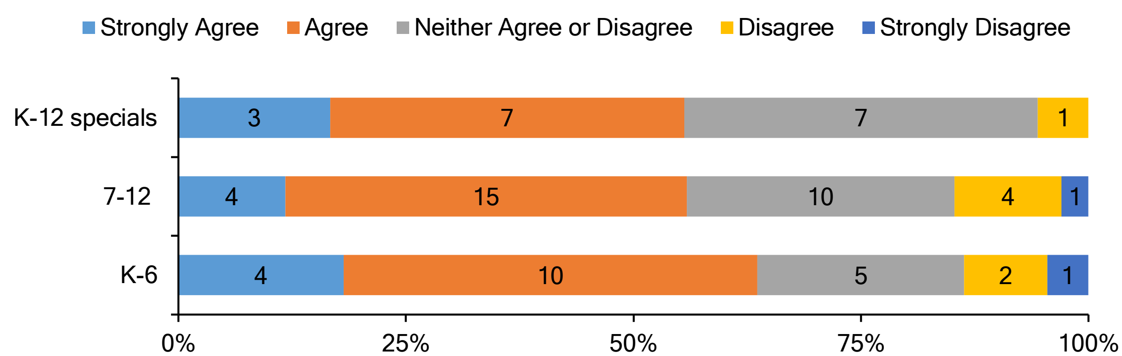


Figure 22 shows the results concerning the effectiveness of technology professional development with a total of 31 of 74 participants or approximately 42% indicating they were indifferent or disagreed to some extent. This may be a result of many new teachers being hired since the 1:1 technology initiative began, poor training, training that is not applicable, or inadequate access to training. The qualitative data collected for Research Question Four (what professional development is needed to support technology integrated instruction?) suggest that subject specific and differentiated technology professional development is important to the staff. For example, participant 16 wrote, “I would love more content specific PD and how to most effectively utilize technology for the benefit of my students.” Participant 23 wrote, "learning different tools in depth, not just a brief two-minute introduction of technology available and then you need to find the time to figure it out." Triangulation is present in the corroborating quantitative and qualitative results between Research Question One and Four and is supported by the literature which indicates that lack of adequate and applicable professional development and time can create many obstacles to effective technology integration (Bebell & Kay, 2010).

Figure 22

Technology Professional Development Was Effective.



The WASD's delivery of technology related professional development has been primarily facilitated through *Technology Integrators*. These are highly trained teachers with content expertise in teaching with technology that receive a stipend to train teachers on integrating technology before and after school and during in-service days. Consistent with research, these positions were created with the intent of providing ongoing flexible hands-on experiences where teachers would have an opportunity to collaborate and see how technology can be applied in their classroom or subject area (Hilaire & Gallagher, 2020; Love et al., 2020). Figure 23 shows that while most participants either Agree or Strongly Agree that the technology integrators are an effective support or resource, Figure 24 reveals that they are being underutilized. These results are a key finding in this capstone project that warrant additional investigation to determine the root cause of teachers underutilizing the Technology Integrators. More effectively deploying this resource is an essential piece in improving the 1:1 technology program.

Figure 23

The Technology Integrators Are an Effective Support or Resource.

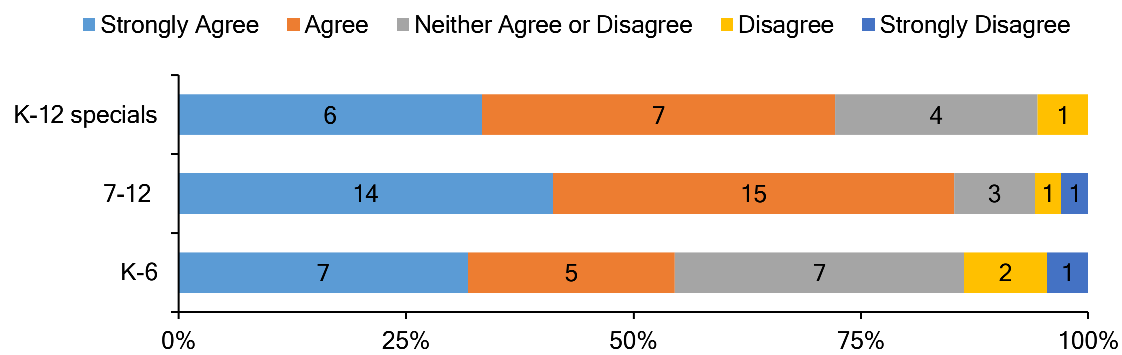
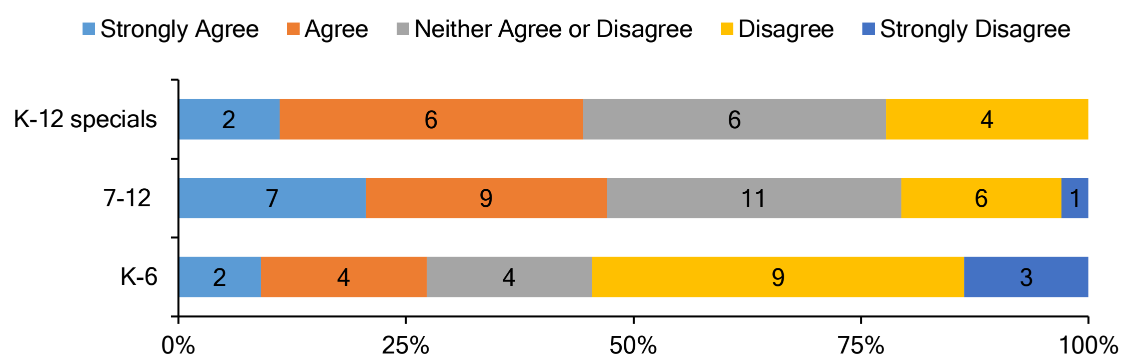


Figure 24

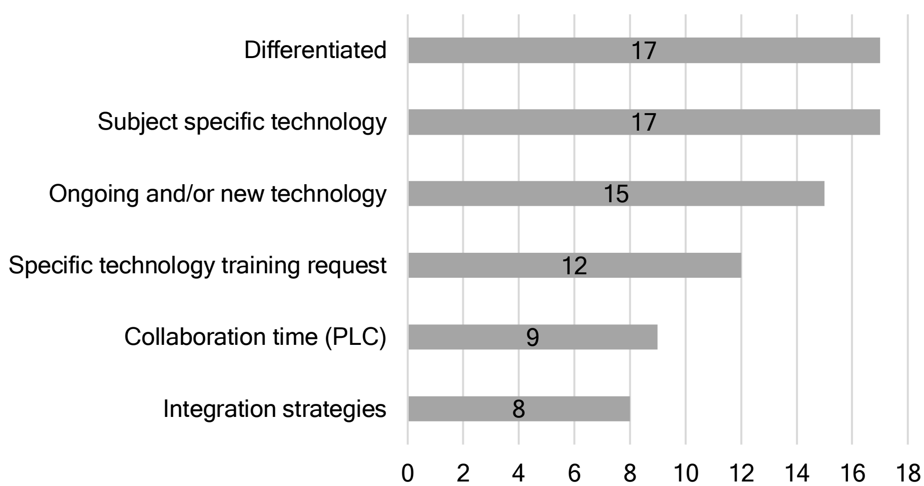
Utilize the Technology Integrators Regularly.



Research Question Four asks, what professional development is needed to support technology integrated instruction? Qualitative data to address this question were collected via a similar open-ended question in the 1:1 technology survey (see Appendix C for 1:1 technology survey). The participant's coded responses are summarized in Figure 25 as a frequency bar graph. The results are consistent with findings in the research about the types of training that are the most beneficial to 1:1 technology integration i.e., differentiated, specific, and ongoing with time for collaboration (Darling-Hammond & Richardson, 2009; Hilaire & Gallagher, 2020; Love et al., 2020).

Figure 25

Professional Development Needed to Support Technology Integration.



1:1 Effectiveness Perception Construct Scores

In addition to the bar graph presentation and analysis of the Likert scale data collected for Research Question One, parametric analysis was also conducted. Average perception construct scores were calculated with Excel from the following Likert items on a 5-point bipolar Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) yielding each candidate a perception Likert scale interval score for the effectiveness of 1:1 technology:

- Students use technology in my classroom for learning every day.
- During lessons that involve student PC use, student engagement is high.
- Student learning is enhanced by PC devices in my classroom.
- The 1:1 PC device initiative is effective for my grade level.

Table 9 shows the mean and standard deviation calculated using the Excel Data Analysis ToolPack for all the participants Likert interval scores as well as subsets categorized by grade level and subject. The K-6 regular, special education, and title teachers group rated the effectiveness of 1:1 technology the highest with a mean Likert interval score of 4.4 and the smallest standard deviation of 0.5. The next highest rating came from the K-12 specials teachers with a mean Likert interval score of 4.1 and a standard deviation of 0.7. The 7-12 teachers mean Likert scale interval score was 3.6 and with standard deviation of 0.8. This variation is observable in the grade level perception Likert bar graphs (Figures 12-16). That is, the K-6 and K-12 special teachers were consistently into the Agree and Strongly Agree range on most items while the 7-12 teachers more often had clusters of teachers in the Neither Agree or Disagree range.

Table 9

Perception of the Effectiveness of 1:1 Technology.

Group	*N*	*n*	*M*	*SD*
All participants	74		4.0	0.8
K-12 specials teachers		18	4.1	0.7
7-12 regular and special education teachers		34	3.6	0.8
K-6 regular, special education, and title teachers		22	4.4	0.5

Average perception construct scores were calculated with Excel from the following Likert items on a 5-point bipolar Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) yielding each candidate a Likert interval perception score for the effectiveness of 1:1 technology professional development:

- I have received professional development on teaching with PC devices in a 1:1 environment.

- The professional development I received on teaching in a 1:1 PC environment was effective.
- The Technology Integrators are an effective support or resource.
- I utilize the Technology Integrators regularly.

Table 10 shows the mean and standard deviation calculated using the Excel Data Analysis ToolPack for all the participants Likert interval scores as well as subsets categorized by grade level and subject. The mean Likert interval score for all participants and subgroups was relatively close to 3.5. Standard deviation for all the teachers and subgroups was relatively close, ranging from 0.7 to 1.0 indicating that the teachers' perception of the effectiveness of 1:1 professional development is somewhat discrepant, fluctuating between Agree and Disagree.

Table 10

Effectiveness Perception: 1:1 Technology Professional Development

Group	*N*	*n*	*M*	*SD*
All participants	74		3.6	0.9
K-12 specials teachers		18	3.6	0.7
7-12 regular and special education teachers		34	3.7	0.9
K-6 regular, special education, and title teachers		22	3.4	1.0

Two-tailed independent samples *t*-tests were calculated with the Excel Data Analysis ToolPack using the Likert interval scores from the K-6 and 7-12 regular and special education teachers. Table 11 shows the results. The K-6 participants have a more positive perception of the effectiveness of 1:1 technology at their grade level that is statistically significant, $p < .001$, $p < .05$, with a mean score of 4.4 as opposed to a mean score of 3.6 for the 7-12 teachers. The *t*-test regarding the teachers' perception of the effectiveness of technology professional development between the K-6 and K-12 participant subgroups, $p = .33$, $p > .05$, indicates that there is not a statistically significant difference in perception.

Table 11

Effectiveness Perception t-tests: Regular and Special Education Teachers

Perception	K-6			7-12				
	n	*M*	*SD*	*n*	*M*	*SD*	*t*	*p*
1:1 technology is effective	22	4.4	0.5	34	3.6	0.8	3.99	$p < .001$*
Technology PD is effective		3.4	1.0		3.7	0.9	-0.99	.33

*$p < .05$.

1:1 Technology Integrated Instruction

Research Question Two asks, how often and to what extent is 1:1 technology integrated into instruction? Data to address this question was gathered in the 1:1 technology survey utilizing Likert items arranged around two research-based technology integration models, SAMR and TPACK. The SAMR Likert items consisted of four singular questions, while the TPACK Likert items required multiple participant responses arranged around each of four TPACK domains (constructs).

SAMR

The SAMR model describes how teachers and students use or incorporate technology into learning. It has four defined levels: Substitution, Augmentation, Modification, and Redefinition. A hierarchy is present with Substitution being the simplest use of technology and Redefinition representing the most complex use of technology integrated teaching and learning (Hilton, 2016). An example of Substitution would be students using a laptop top to take notes and an example of Augmentation would be accessing the spellcheck function of a world processor to improve spelling and grammar. The Substitution and Augmentation levels of use do not require technology to achieve but technology *enhances* the task by making it more efficient, accessible, etc. Participant responses summarized in Figures 26 and 27 show that Substitution and Modification occur with considerable frequency across all subjects and grade levels at a combined level of Always, Often, and Sometimes of 91% and 81% respectively.

Figure 26

Substitution Occurs in My Classroom:

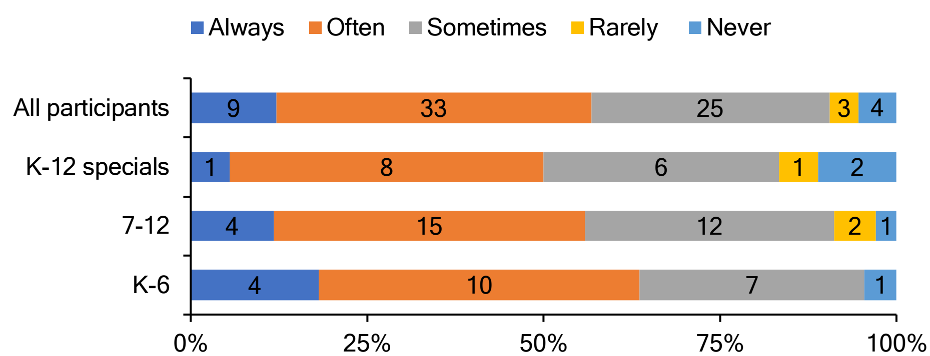
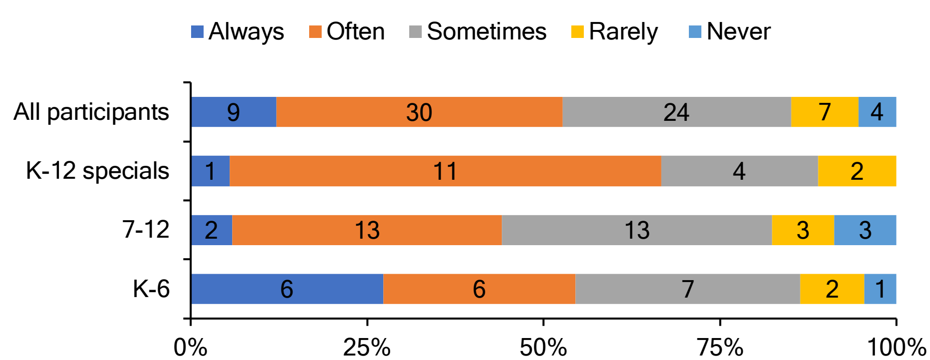


Figure 27

Augmentation Occurs in My Classroom:



Instruction at the Modification and Redefinition levels involve learning activities that cannot be achieved without technology (Kurbaniyazov, 2018). For example, making multimedia presentations that incorporate student narration, custom video, detailed graphics, and original music. Specifically, learning is *transformed* through a deliberate and complicated merging of technology with instruction. Figures 28 and 27 show that the reported frequency of these activities is low for Modification and Redefinition with only 51% and 28% respectively for the combined categories of Often and Sometimes.

Figure 28

Modification Occurs in My Classroom:

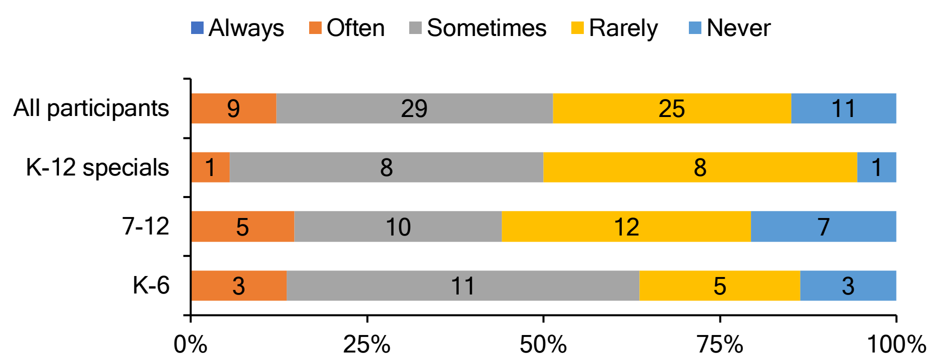
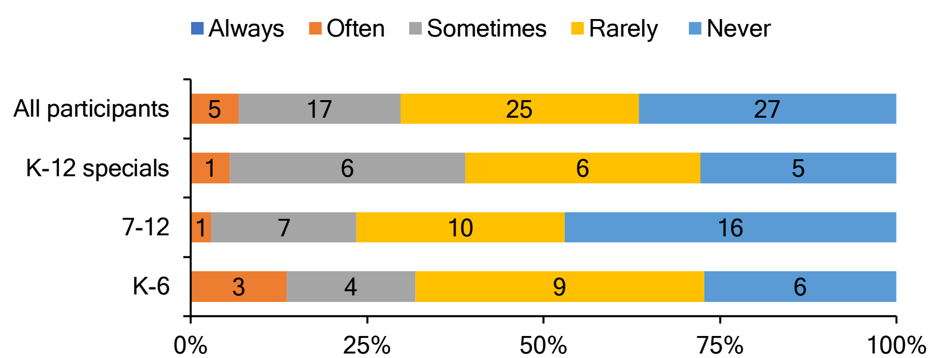


Figure 29

Redefinition Occurs in My Classroom:



The SAMR framework is like the hierarchy of Bloom's Taxonomy in that the most complicated learning occurs at the top of both models, i.e., *Redefinition* (SAMR) and *Create* (Bloom's). It is therefore not surprising that Modification and Redefinition activities were reported as occurring with less frequency by the participants because there is natural setup time leading to more complex learning. Activities at the lower levels of both hierarchies need to occur with regularity to prepare students and teachers for higher level activities which requires time. Because research suggests that higher level technology integrated instruction has learning benefits (Hilton, 2016; Romrell et al., 2014), this is an area for further investigation to determine if there are ways to maximize Modification and Redefinition opportunities in the 1:1 initiative.

TPACK

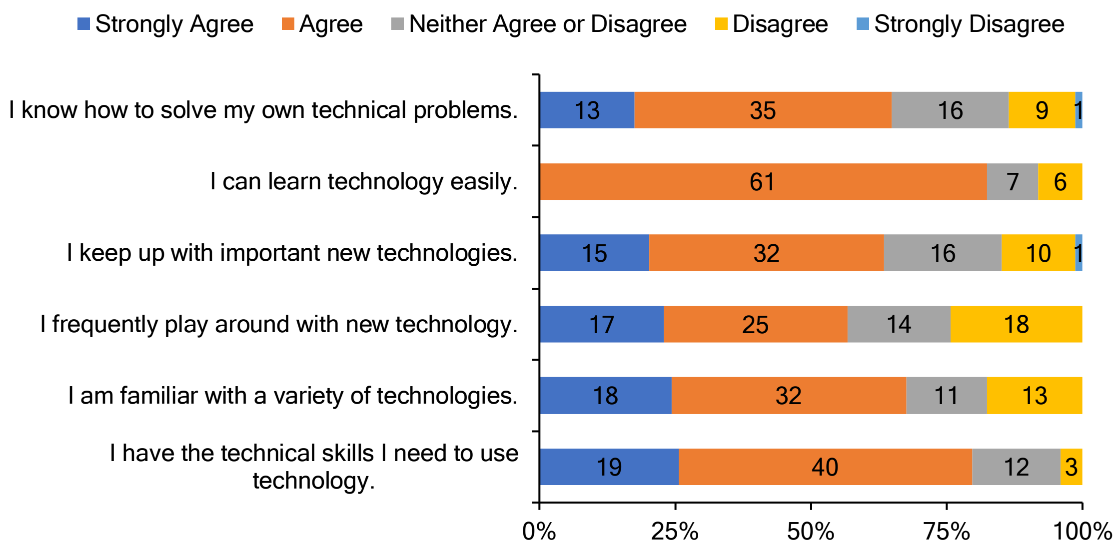
The TPACK model was used to assess the teachers' level of knowledge in each of the technology-specific related domains of the model as described in the literature (Eutsler, 2020; Schmidt et al., 2009). The assessed areas in the 1:1 technology survey included Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and finally all the components collectively, Technology, Pedagogy, and Content Knowledge (TPACK).

Figure 30 summarizes all 74 participants' results for the TK domain. The participants reported very high levels of competence in TK with combined Agree and Strongly Agree of approximately 80% or higher in the areas of being able to learn new technology skills easily and having the skills needed to use technology. Only 20% percent of the participants reported having the necessary skills to use technology at a combined rating of Neither Agree or Disagree, or Disagree. Although the lowest combined Agree and Strongly Agree rated Likert items in the TK domain addressed solving their own technical problems, keeping up with new technologies, and experimenting with new technology, these areas were still all rated at approximately 65%

or higher indicating a great degree of technical competence among the participants.

Figure 30

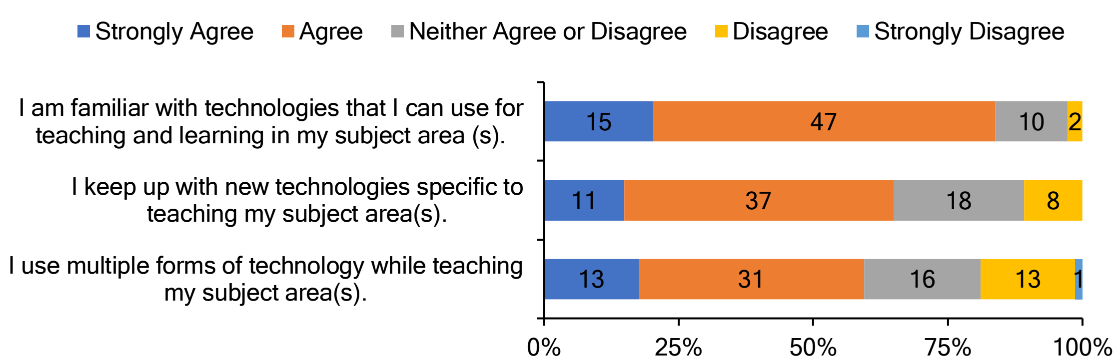
Technological Knowledge (TK)



The TCK domain of Likert items also received strong combined Agree and Strongly Agree ratings with familiarity of subject area specific technologies being assessed the highest at approximately 84% (Figure 31).

Figure 31

Technological Content Knowledge (TCK)



The TPK Likert items revealed the overall highest combined ratings of Agree and

Strongly Agree of at least 71% or greater except for being able to provide technology leadership, which was rated at 51% (Figure 32). This indicates the participants are very confident with technology pedagogy.

Figure 32

Technological Pedagogical Knowledge (TPK)

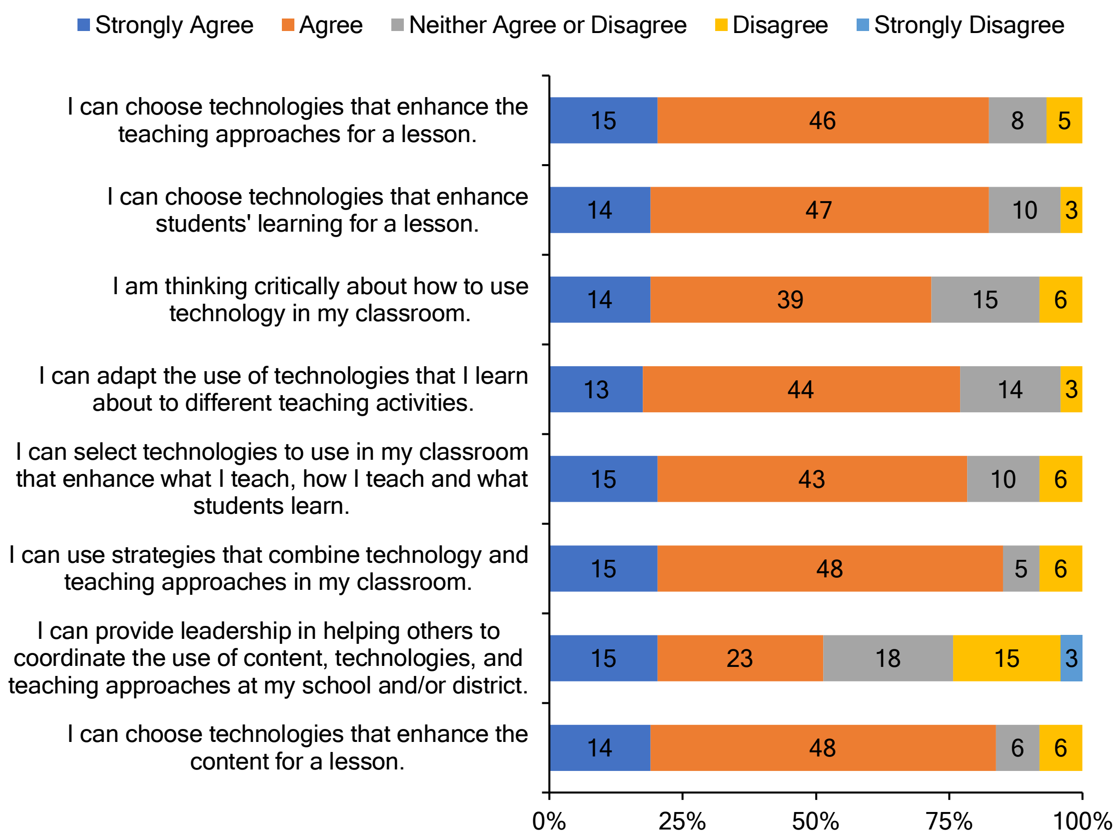
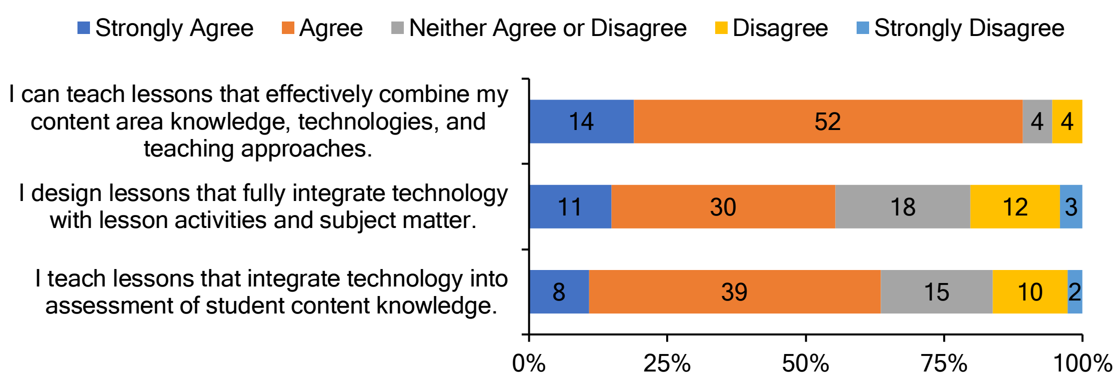


Figure 33 shows the teachers' self-assessment of all the TPACK domains together. The first Likert item prompted participants about their individual competence in combining content knowledge, technology, and teaching approaches. The combined Agree and Strongly Agree rating was 89%. The second Likert item was more global, assessing their ability to *fully integrate* technology into teaching. The combined rating for this item was considerably less at 54% indicating that there is room for growth and professional development in the TPACK domain. These results are consistent with the research and are in line with the similar SAMR Likert assessment of Modification and Redefinition activities. That is, fully integrating all the elements of technology and teaching represents a very high level of technology knowledge and pedagogy that does not necessarily lend itself to frequency in the daily classroom experience.

Figure 33

Technological Pedagogical and Content Knowledge (TPACK)



TPACK Construct Scores. In addition to the bar graph presentation and analysis of the Likert scale data collected for Research Question Two, parametric analysis was also conducted. Average TPACK construct scores were calculated with Excel on a 5-point bipolar Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) yielding each candidate a Likert interval score for each TPACK domain. For example, the six questions under TK (Technology Knowledge) were averaged to produce one TK score for each participant. Like the bar graph analysis, Table 12 shows that the teachers are the most confident in the TPK domain with a mean score of 3.9 and a relatively low standard deviation of 0.7. Overall mean scores are rather consistent across grade level and subjects, although the K-6 teachers indicate a relatively high degree of confidence in the TK domain with a mean score of 3.8 and a standard deviation of 0.6. This is consistent with the generally more positive perception of 1:1 technology revealed in the survey data among the K-6 participants over the 7-12 participants.

Table 12

TPACK Domain Likert Scale Interval Scores

Domain	All			K-12 Specials			7-12			K-6		
	N	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
TK	74	3.7	0.8	18	3.8	0.9	34	3.7	0.8	22	3.8	0.6
TCK		3.8	0.7		3.9	0.7		3.8	0.7		3.7	0.8
TPK		3.9	0.7		4.1	0.6		3.8	0.8		3.8	0.6
TPACK		3.7	0.8		3.6	1.0		3.6	0.8		3.8	0.7

Two-tailed independent samples *t*-tests were calculated with the Excel Data Analysis ToolPack using the Likert interval scores in each TPACK domain from the K-6 and 7-12 regular and special education teachers. The results did not reveal any statistically significant differences between the K-6 and 7-12 grade level groups with all *p* values being greater than 0.05 (Table 13).

Table 13

TPACK Domain t-tests: Regular and Special Education Teachers

Domain	K-6			7-12				
	n	M	SD	*n*	M	SD	*t*	*p*
TK	22	3.8	0.6	34	3.7	0.8	0.30	.767
TCK		3.7	0.8		3.8	0.7	-0.36	.717
TPK		3.8	0.6		3.8	0.8	0.32	.750
TPACK		3.8	0.7		3.6	0.8	0.89	.376

Summary

The primary focus of this Doctoral Capstone Project was to examine the efficacy of WASD's 1:1 technology initiative with a secondary focus to assess potential differences between implementation at the primary (K-6) and secondary (7-12) levels. The 1:1 technology survey collected a variety of quantitative and qualitative data to examine the program's effectiveness in terms of the teachers' general perception of its effectiveness, strengths and weaknesses, professional development, and instructional integration in terms of the SAMR and TPACK frameworks.

The quantitative and qualitative survey data indicate that the overall perception of the effectiveness of 1:1 technology is positive among all participants. Many of the research-based benefits of 1:1 technology such as increased access to technology and information, differentiated instruction, and extended learning opportunities were cited consistently in the qualitative data as shown in Figure 19 (Zheng et al., 2016). However, the Likert interval score data show that the K-6 participants rated 1:1 technology effectiveness significantly higher than the 7-12 participants as determined by a two-tailed independent samples *t*-test (Table 11). The qualitative data collected through open-ended questions regarding the strengths and weaknesses of 1:1 technology suggests that the technology is positively impacting the educational environment through increased access (Figure 19) but also reveals that there are challenges to be addressed such as inadequate collaboration time and technical problems (Figure 20).

Participant perception of the professional development provided in relation to the 1:1 initiative was mixed. The K-6 participants rated the professional development effectiveness higher than the 7-12 group; however, the difference was not statistically significant (Table 11). Delivery of professional development by the Technology Integrators was rated positively overall by both groups, but the data suggests that this resource is underutilized. The Technology Integrator peer-lead collaborative approach to professional development is supported by the research (Hilaire & Gallagher, 2020; Love et al., 2020). Therefore, improving access to the Technology Integrators is important to increasing their overall effectiveness. The qualitative data collected via an open-ended question suggest that improvement of 1:1 technology professional development requires more differentiated and subject specific training followed with adequate peer collaboration time (Figure 25). This qualitative data triangulates clearly with the quantitative Likert data and is supported by the research (Darling-Hammond & Richardson, 2009).

The researched-based SAMR and TPACK models of technology-integrated instruction were used to examine how often and to what extent 1:1 technology is integrated into instruction. Both models are similar in that they imply a hierarchy of integration. In SAMR, Substitution and Augmentation level use of technology in the classroom involves using technology in ways that could also be done traditionally such as note taking and proofreading; whereas Modification and Redefinition level activities represent a higher level of integration and cannot be done without technology such as creating multi-media presentations. The Likert data indicates that Substitution and Modification occur with considerable frequency across all subjects and grade levels while Modification and Redefinition were primarily rated as occurring only occasionally.

The TPACK model breaks down the various components of technology-integrated instruction into domains. Likert data for the first domain, Technology

Knowledge (TK) indicates that the participants are very comfortable with technology. Similarly, the participants reported a high degree of competence in the Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) domains. One of the lower rated Likert items was “designing lessons that fully integrate technology with lesson activities and subject matter.” This item is from the Technological Pedagogical and Content Knowledge (TPACK) domain representing the highest level of technology-integrated teaching. Like the SAMR results, the TPACK data indicate higher level technology-integrated instruction is occurring with less frequency in the 1:1 technology initiative. The research suggests there are benefits to higher levels of technology-integrated instruction (Hilton, 2016; Romrell et al., 2014). Therefore, exploring ways to increasing its frequency could improve the WASD 1:1 initiative. Finally, independent samples *t*-tests conducted using the TPACK Likert interval scores between the K-6 and 7-12 participants revealed no statistically significant differences between the groups (Table 13). The next chapter will examine these results in terms of each research question to draw conclusions and make specific recommendations for improvement of the WASD 1:1 technology initiative.

Chapter V

Conclusions and Recommendations

The purpose of this Doctoral Capstone Project was to examine the effectiveness of the implementation of a 1:1 student technology initiative in the Wattsburg Area School District. Over a period of approximately six years, the District made a substantial investment in technology infrastructure, student and staff PC devices, and professional development with the goal of effectively integrating technology into instruction. Fiscal considerations are significant with the annual and ongoing investment for the initiative averaging $700,000 for a total investment of about $5.6 million over the past eight years. This action research project utilized a teacher survey to gather the teachers' perceptions of several key aspects of the 1:1 initiative including overall effectiveness, related professional development, depth of technology integration, and strengths and weaknesses (see Appendix C for 1:1 technology survey). This chapter will state conclusions related to each of the study's four research questions along with recommendations for improving the 1:1 program, including fiscal implications.

Conclusions

The overall data analysis and results indicate that the 1:1 technology initiative is effective and has enhanced both student learning and technology-integrated instruction. For example, most participants indicated that student learning is enhanced by PC devices in their classrooms. Regarding technology-integrated instruction, participants stated that 1:1 technology has improved access to technology and increased differentiated instruction. However, there are areas in need of improvement such as more specific and frequent technology professional development. The results also indicate the need for adequate time to collaborate during professional development and guidance with technology-integrated instruction for specific subjects such as math and science. Finally, the SAMR and TPACK model data suggest that lower-level technology-integrated instructional activities occur regularly, but that higher-level activities such as Modification and Redefinition occur infrequently which is another area in need of research and improvement.

Research Question One

What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment? Data to address this question were collected via the 1:1 technology survey regarding the effectiveness of 1:1 technology in the classroom as well as the related technology professional development and resources provided to the staff. Several conclusions can be made from the data analysis and results related to Research Question One.

Conclusion One

The 1:1 technology initiative is effective. This conclusion is supported by the overall positive participant effectiveness ratings from the Likert items regarding frequency of use, student engagement, enhanced learning, and grade level. None of these teacher perceptions of 1:1 technology effectiveness Likert items had a combined Agree and Strongly Agree rating of less than 50%, with most combined positive ratings well above 70%. The Likert ratings for the effectiveness of 1:1 technology for instruction in specific subject areas like ELA, math, and science were mixed. ELA had a combined Agree and Strongly Agree rating of 75% at both the K-6 and 7-12 levels, while math and science were rated closer to 50%. The qualitative data also support these results.

However, the sample sizes were relatively small for these subject specific Likert items, so this is an area for further investigation and action.

Implications. Although the data supporting Conclusion One indicates that 1:1 technology is effective and has enhanced the learning environment, the data also suggest that the effectiveness of 1:1 technology may vary by subject. For example, teachers' perceptions in the subject areas of math and science were relatively low at the K-6 and 7-12 levels. To improve technology-integrated instruction, meetings will be scheduled with all K-12 subject area teams, the Curriculum Director, and Technology Integrators to discuss the use of technology in their subject area and what types of professional development or resources are needed to improve technology-integrated instruction. In the short-term, there could be fiscal implications ranging from additional costs for specific professional development, to the purchasing of specialized software and supporting devices. A long-term fiscal implication entails adding subject-specific Technology Integrators and providing them specialized training to facilitate a self-sustaining Professional Learning Community (PLC) as supported by the research (Love et al., 2020). Currently there are six Technology Integrators at a cost of $4,098 each for stipends. To add a math and science Technology Integrators to each of the District's three schools will add an annual recurring cost of approximately $24,500 plus specialized training expenses. Other subject-specific Technology Integrators may be needed as well.

Conclusion Two

The 1:1 technology initiative is perceived as more effective at the K-6 level than the 7-12 level. Although both the 6-12 and 7-12 participants rated 1:1 technology effectiveness positively overall, the combined Likert interval score for K-6 participants was higher than the 7-12 participants' score, which was statistically significant as determined by a two-tailed independent samples *t*-test.

Implications. This is an area for further investigation and action. The reasons for the difference in perception between K-6 and 7-12 may be revealed through the action items outlined in the implications for Conclusion One and addressed in a similar manner.

Conclusion Three

Delivery of technology professional development is only moderately effective at both the K-6 and 7-12 levels. The professional development Likert data to support this conclusion shows that approximately 50% of all participants in the study Agreed or Strongly Agreed that it was effective. And although most participants rated the Technology Integrators as an effective support or resource (for professional development), just 36% of participants indicated that they utilize them on a regular basis. Comparison of the combined Likert interval scores between the K-6 and 7-12 participant subgroups did not indicate that there was a statistically significant difference in the perception of professional development as determined by a two-tailed independent samples *t*-test. In other words, these subgroups share a similar perception of the effectiveness of technology professional development.

Implications. The data supporting conclusion one indicates that there is an obstacle in how technology professional development is being delivered and accessed, which could account for the relatively low effectiveness ratings. Technology professional development has primarily been provided by the Technology Integrators on an as needed basis or at voluntary instructional sessions held before or after the school day. Clearly, this is not producing effective results. This can be addressed without fiscal implications. The teachers' collective bargaining agreement requires up to 30 hours of teacher meeting and collaboration time outside the school day. Traditionally, this time has been used for faculty meetings or miscellaneous trainings and other meetings. These hours can be reorganized to allow for regular technology professional development sessions and collaboration time each month delivered by the Technology Integrators. This is consistent with the research that supports ongoing professional development collaboration results in the strongest technology-integrated instruction (Durff & Carter, 2019; Ismajli et al., 2020; Love et al., 2020).

Research Question Two

How often and to what extent is 1:1 technology integrated into instruction? Data to address this question was gathered via the 1:1 technology survey utilizing Likert items arranged around two research-based technology integration models, SAMR and TPACK. Both models categorize technology-integrated instruction in a hierarchy that delineates the extent to which technology is infused into instruction. On the low-end, technology simply replaces or enhances traditional classroom practice. On the high-end, technology is integrated into instruction in such a way that lessons and learning activities cannot be accomplished without it.

Conclusion Four

Lower-level technology-integrated instruction occurs regularly at both the K-6 and 7-12 levels, but higher-level activities that cannot be accomplished without technology occur infrequently. This conclusion is supported by the SAMR Likert items that indicate that lower-level activities classified as Substitution and Modification occur with considerable frequency across all subjects and grade levels at a combined level of

Always, Often, and Sometimes of 91% and 81% respectively. The more complicated activities classified as Modification and Redefinition occur with much less frequency with ratings of 51% and 28% respectively for the combined categories of Often and Sometimes. The TPACK data supports this with overall ratings in each of the TPACK domains revealing that the participants are confident with technology pedagogy and content knowledge but less confident with designing lessons that fully integrate technology with lesson activities and subject matter. Furthermore, two-tailed independent samples *t*-tests calculated in each TPACK domain using Likert interval scores did not reveal any statistically significant differences between the K-6 and 7-12 grade level regular and special education subgroups.

Implications. Research suggests that higher-level technology integrated instruction has learning benefits (Hilton, 2016; Love et al., 2020). Improving the depth of technology-integrated instruction can be addressed by improving professional development as outlined in the implications for Research Question One. This is also an area for further research.

Research Question Three

What are the strengths and weaknesses of technology integrated teaching and learning? Qualitative data to address this question were collected via two open-ended survey questions (see Appendix C for 1:1 technology survey).

Conclusion Five

The 1:1 technology initiative is altering and enhancing teaching and learning despite challenges. The coded participant responses supporting this conclusion indicate that the benefits of 1:1 technology found in the research is occurring in classrooms such as ease of access to technology and information, differentiated instruction, and increased teaching options, and enhance communication between students, parents, and teachers (Zheng et al., 2016). These results further support and triangulate with Conclusion One, that the 1:1 technology initiative is effective. However, the coded qualitative data collected indicate that there are challenges such as inadequate time to learn and collaborate, technical problems, and difficulty integrating technology with specific subject matter such as math.

Implications. Most of the identified 1:1 technology challenges can be addressed by improving professional development as previously discussed and will be addressed further in Conclusion Six. The frequently coded response of technical problems requires additional investigation to identify steps to reduce its actual or perceived occurrence. The first step is to determine if the technical problems are related to the technology devices and network, software, or user knowledge/error. This investigation will begin with a meeting of the technology department, curriculum director, and Technology Integrators to review and discuss a full year report of submitted technology work tickets including type, resolution steps, and average time to close tickets. Fiscal implications could include hiring additional technicians to increase access to technology support. The cost of adding an additional technician would be approximately $63,500 including salary and benefits. Other fiscal implications could involve replacing or upgrading equipment or adjusting the current technology infrastructure.

Research Question Four

What professional development is needed to support technology integrated instruction? Qualitative data to address this question were collected via one open-ended survey question (see Appendix C for 1:1 technology survey).

Conclusion Six

Technology professional development is inadequate in terms of type, time, and content. The coded participant responses that support this conclusion are consistent with what the research indicates produces the most effective technology professional development. That is, the most frequent coded participant responses requested technology professional development that is differentiated, subject or content specific, and ongoing with adequate time for collaboration (Darling-Hammond & Richardson, 2009; Hilaire & Gallagher, 2020; Love et al., 2020).

Implications. These results further support and triangulate with Conclusion Three, that the delivery of technology professional development has only been moderately effective. The data also identified the type and content of professional development the District should focus on to improve the 1:1 initiative in addition to the recommendations for increasing the frequency of trainings and collaboration time as outlined in implications of Conclusion Three.

Limitations

This action research study has various limitations related to its design, the COVID-19 pandemic, and the sample size of certain subgroups. In order of potential impact on the study's conclusions, the limitations are:

1. inherent weaknesses of Likert scale data
2. accelerated technology adoption and use due to periods of distance learning necessitated by the COVID-19 pandemic
3. sample size of the K-6 participants

4. sample size of 7-12 participants regarding Likert scale items related to 1:1 technology integration in specific subjects such as math and science

Limitation One

Likert scales are used frequently in research because they are a convenient way to quickly collect a large amount of data. They are also simple to construct and easy for participants to understand and complete (Bertram, 2006). However, Likert scales have several documented weaknesses such as:

- central tendency bias - participants may avoid extreme response categories
- acquiescence bias - participants may agree with statements as presented in order to “please” the experimenter
- social desirability bias - portray themselves in a more socially favorably light rather than being honest
- lack of reproducibility
- validity may be difficult to demonstrate - are you measuring what you set out to measure? (Bertram, 2006, p. 7)

Central tendency bias was not observed in this study’s results as a relatively large number of Likert items resulted in high numbers of participants responding Agree or Strongly Agree. However, this may suggest some acquiescence and social desirability bias because the researcher is the Superintendent of the Wattsburg Area School District. This possibility was anticipated, so several measures were taken to control for this limitation. First, the convergent parallel research design utilized triangulation between Likert scale items and open-ended questions. Second, the use of constructs in the survey design to create Likert scale interval scores allowed for the use of parametric statistical analysis to mitigate participant bias when interpreting the results. And third, the TPACK Likert survey items used in this study were obtained and used with permission from the original researchers of this model (Schmidt et al., 2009), who vetted the validity of the survey's internal consistency using Cronbach's alpha reliability technique.

Limitation Two

When the pandemic forced school closures around the world in March 2020, educators were pressed to pivot very quickly to technology for remote learning. During this abrupt transition, many challenges arose that required quick solutions that impacted policies and procedures (Huck & Zhang, 2021). The Wattsburg Area School District experienced several challenges with the initial distance learning solution hastily assembled in the spring of 2020. The biggest challenge was lack of student internet access at home due to the very rural nature of the WASD. An ad hoc survey revealed that approximately 50% of the students in Grades K-12 did not have high speed internet access. Distribution of cellular hotspots to students and teachers took several weeks. During this time, we discovered that the reliability and internet speed of the hotspots varied significantly which severely limited the option to live stream lessons. Instead, an asynchronous solution involving OneDrive folders for each teacher and course were used for remote instruction through the end of the 2019-2020 school year. This solution proved to be very ineffective and frustrating for students and staff.

Based on what was learned during the initial distance learning attempt, the Administrative Team and Technology Integrators took time to develop a more comprehensive solution using the Microsoft Teams platform. This plan included professional development that was rolled out during the summer of 2020. Teachers needed instruction on how to set up their courses in Teams using a standard template that could be easily leaned by students and parents. Policies and procedures were also developed for taking virtual attendance which required students to log into each Teams class following their normal in-school daily schedule. Although these measures improved the quality of distance learning, there were still limitations such as poor internet speed which continued to hamper attempts to live stream mini lessons. The solution to this problem involved having teachers record their live streamed lessons so that students with slow internet access could download and watch them as their connection permitted. The Microsoft Teams distance learning solution was an overall large improvement but remained primarily asynchronous.

The pandemic effected the implementation of the 1:1 technology initiative. When schools were forced to close periodically due to COVID-19 outbreaks, the WASD was partially prepared because of a recently achieved 1:1 ratio of PC devices to students. Teachers also received professional development regarding technology-integrated instruction. Still, technology use was varied among the staff with early adapters fully embracing 1:1 technology in the classroom while others experimented with much more modest use. The pandemic disrupted the planned 1:1 initiative implementation by diverting the focus away from a steady transition to technology-integrated instruction in the classroom to mandatory technology use for periods of distance learning. This situation pushed technology adoption and use by all teachers, which may have positively impacted their perception and use of technology when they returned to the face-to-face setting. Pryor et al. (2020) found that distance learning had many positive effects such as "independent learning, higher level thinking, organization, use of technology to individualize learning, and improved communication with stakeholders" (p. 6). This is an area worthy of additional research.

Limitation Three

Overall participation and sample size for this study was good. A total of 74 or 72.5% of the 102-member faculty completed the 1:1 technology survey. However, the survey data revealed that participation of the teachers from the District's K-4 elementary school was low. Only about 50% of the elementary school's faculty completed the 1:1 technology survey. To encourage participation from all faculty members, the survey was administered at faculty meetings so that completion would not require extra time outside of the school day. Due to the building schedules, the middle school (Grades 5-8) and high school (Grades 9-12) were able to meet in the morning and early afternoon respectively while the elementary school meeting was held after students were dismissed at 4:00 p.m. This later meeting time at the end of a full school day may account for the lower participation level. Even so, the total number of participants classified as K-6 teachers was 22, which is an acceptable sample size. If more elementary teachers participated, the total number of K-6 teachers would have been closer to 36, which may have increased reliability regarding the K-6 level results.

Limitation Four

The 1:1 technology survey included Likert items for regular education math and science teachers at the grade 7-12 level that asked them to rate the effectiveness of 1:1 technology in their respective subjects. The results were split with about half of the participants rating Agree or Strongly Agree that 1:1 technology is effective in math and science. The sample size was small with just six math teachers and seven science teachers that responded. This is because there are only a total of six math teachers and eight science teachers at the 7-12 level in the District. So, although nearly 100% of the 7-12 math and science teachers participated, the sample size precluded drawing conclusions beyond a face value interpretation that this is an area of concern among the participants. Similar concerns were also mentioned in some of the qualitative data regarding integrating 1:1 technology into specific subjects, and math in particular.

Recommendations for Future Research

There are several areas that would benefit from future research that emanate from the results and conclusions of this Doctoral Capstone Project. The first recommendation is to study the most effective ways to integrate technology into specific subjects such as math and science. This is supported by Conclusion Five that notes the need to deliver subject specific professional development to assist teachers connect specific content material with technology-integrated instruction. Some of this research could be accomplished as an action research project in the District, but a better understanding would most likely come from field research i.e., visits to other schools outside the District that are effectively utilizing technology in subjects such as math and science. In addition, such research would benefit from an exploration of specialized software designed to facilitate subject specific instruction with technology beyond the use of common tools and platforms such as Office 365 applications.

Conclusion Four recognizes that high level 1:1 technology integrated instruction and learning activities defined by the SAMR model as Modification and Redefinition occur infrequently. The research indicates that this type of technology integration has academic benefits. So, the second recommendation for research is an examination of technological pedagogy and knowledge needed to increase the occurrence of higher-level technology-integrated instruction as described by the SAMR and TPACK frameworks. This is an extension of the first recommendation because the result of such research would ideally lead to professional development and further the development of self-sustaining PLCs within the District.

This Doctoral Capstone Project studied the effectiveness of the 1:1 initiative as measured by the teachers' perceptions of how it has impacted the educational environment and changed teaching and learning. A natural extension of this study is to examine the effects of 1:1 technology on student achievement. A study designed for this purpose should include an analysis of quantitative student performance data that has some level of standardization such as benchmark assessments. This could be accomplished by coupling the student achievement research with the roll out of professional development generated by the first and second research recommendations. For example, if research reveals an effective subject specific technology application and associated pedagogy for teaching algebraic concepts, the related professional development could employ a student pre and post benchmark assessment as it is delivered to measure its impact on student achievement. A potential study design would utilize a randomized control group or classroom that would learn the algebraic concepts in a traditional manner and then their pre and post benchmark results would be compared to the pre and post benchmark results of the classroom that learned the algebraic concept from a trained teacher utilizing the research-based technology application and associated pedagogy. This approach would also allow for insight into the effectiveness of the professional development. In summary, these three research recommendations outline additional research questions.

Additional Research Questions

1. What are the most effective ways to integrate technology into specific subjects such as math and science?
2. What technological pedagogy and knowledge is needed to increase the occurrence of higher-level technology-integrated instruction as defined by the SAMR and TPACK frameworks?
3. How does 1:1 technology-integrated instruction effect student achievement?

Summary

This Doctoral Capstone Project examined the efficacy of the implementation of a 1:1 student technology initiative in the Wattsburg Area School District. The study collected a large amount of data from 74 teacher participants using a 1:1 technology survey that incorporated key findings and concepts from the review of literature, which included study to develop effective methodology for the project. The project was focused on four research questions and the resulting data analysis yielded six conclusions:

1. The 1:1 technology initiative is effective.
2. The 1:1 technology initiative is perceived as more effective at the K-6 level than the 7-12 level.
3. Delivery of technology professional development is only moderately effective at both the K-6 and 7-12 levels.

4. Lower-level technology-integrated instruction occurs regularly at both the K-6 and 7-12 levels, but higher-level activities that cannot be accomplished without technology occur infrequently.
5. The 1:1 technology initiative is altering and enhancing teaching and learning despite challenges.
6. Technology professional development is inadequate in terms of type, time, and content.

The study's conclusions indicate that the 1:1 technology initiative has been effective in changing and enhancing the educational environment in the Wattsburg Area School District. The conclusions also generated implications that will be used to improve the 1:1 technology initiative. The primary result of this study's findings will be a focus on improving both the delivery and type of professional development related to teaching with 1:1 technology. This will entail making better use of existing teacher time available outside of the regular school day to allow for adequate collaboration centered around specific technology professional development delivered on a regular basis by the Technology Integrators.

Fiscal implications to make the recommended improvements are minimal in comparison to the overall annual cost of the 1:1 initiative. Potential cost increases include adding an additional six Technology Integrators to support specific subjects at a cost of approximately $24,500 plus specialized training expenses. Depending on the post study research described in the study's implications, additional technicians may be needed to ensure adequate technical support is available in a timely manner. Each additional technician would cost approximately $63,500. When these costs are considered in relation to the overall annual investment in the 1:1 technology program of over $700,000, they represent responsible expenditures to improve the effectiveness of the program to ensure that the students are provided with the best possible modern learning environment.

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APPENDICES

Appendix A

1:1 Technology Initiative Survey Consent

Dear Professional Staff Member,

I am currently pursuing a Doctorate in Educational Leadership at California University of Pennsylvania. For my Capstone Research Project, I am conducting a study to investigate the effectiveness of our District's 1:1 student computer program. The data for this study will be conducted via a voluntary online survey. The survey will collect some general demographic information about you such as your gender, age range, number of years teaching, and the subject(s) you teach. The survey will also ask you about your perceptions of computer use by students in your classroom for learning as well as your integration of technology into your teaching pedagogy.

Your participation in this study is voluntary and can be discontinued at any time without question and all data will be immediately discarded. You will not benefit from participating, nor will nonparticipation have any negative effects. Also, all data collected will be anonymous meaning that it will not be traceable back to you. Your individual results will be kept confidential, and all data will be stored electronically with password protection. There is no known risk to participating in the study.

I want to thank you in advance for considering participation in this study. The study results will help our school district understand how you use technology with our students and how we can better support you in the classroom in this endeavor. Note that completing the survey will indicate your consent to participate and have your data used in the study.

This Capstone research project has been approved by the California University of Pennsylvania Institutional Review Board. This approval is effective 09/01/2021 and expires 07/30/2022. The Wattsburg Area School District Board of Directors also approved this research project on 09/20/2021. If you have questions about this Capstone research project, please contact Ken Berlin at BER3520@calu.edu or 814-722-7050. If you would like to speak to someone other than the researcher, please contact Dr. Todd Keruskin, California University of Pennsylvania Capstone Committee Faculty Chair, at keruskin@calu.edu or 412-896-2310.

Many Thanks,

Ken Berlin

Appendix B

IRB Approval

Institutional Review Board
California University of Pennsylvania
Morgan Hall, Room 310
250 University Avenue
California, PA 15419
instreviewboard@calu.edu
Melissa Sovak, Ph.D.

Dear Kenneth,
Please consider this email as official notification that your proposal titled "Analysis of a One-to-One Technology Initiative: Examining Implementation at the Elementary and Secondary Levels" (Proposal #21-001) has been approved by the California University of Pennsylvania Institutional Review Board as amended with the following stipulations:

- Approved contingent upon adding an additional statement in the cover letter explicitly stating that staff members will not benefit from participating (nor will they be in any way harmed by not participating). There's just a slight concern about perceived coercion since the researcher is the district superintendent.
- Permission from someone with the authority in the district (School Board or School Board President) that would not report to the superintendent (applicant).
- Will need Dr. Keruskin's signature on the PD Certification page
- Survey Demographics Q1 suggestion (or more inclusive alternate gender question): For example, To which gender identity do you most identify? M, F, Not listed, prefer not to answer

Once you have completed the above request you may immediately begin data collection. You do not need to wait for further IRB approval. At your earliest convenience, you must forward a copy of the changes for the Board's records.

The effective date of the approval is 09/02/2021 and the expiration date is 09/01/2022. These dates must appear on the consent form.
Please note that Federal Policy requires that you notify the IRB promptly regarding any of the following:

(1) Any additions or changes in procedures you might wish for your study (additions or changes must be approved by the IRB before they are implemented)
(2) Any events that affect the safety or well-being of subjects
(3) Any modifications of your study or other responses that are necessitated by any events reported in (2).
(4) To continue your research beyond the approval expiration date of 09/01/2022 you must file additional information to be considered for continuing review. Please contact instreviewboard@calu.edu. Please notify the Board when data collection is complete.

Regards,
Melissa Sovak, Ph.D.
Chair, Institutional Review Board

Appendix C

1:1 Technology Survey

1:1 Technology Survey

Consent:

- This survey is part of a research study being conducted to better understand how 1:1 technology is being used by teachers and students in the Wattsburg Area School District.
- Note that 1:1 means that every student has access to a computer each day or a computer is assigned to them such as a laptop or tablet.
- Your participation in this study is voluntary and can be discontinued at any time without question and all data will be immediately discarded.
- **All data collected will be anonymous** meaning that it will not be traceable back to you.
- You will not benefit from participating, nor will nonparticipation have any negative effects.
- Your individual results will be kept confidential.
- All data will be stored electronically with password protection.
- There is no known risk to participating in the study.
- Completing the survey **will indicate your consent to participate** and have your data used in the study.

This survey takes approximately 7-10 minutes to complete.

Thank you for taking time to complete this survey. Please answer each question to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. Your individual name or survey number will not at any time be associated with your responses. Your responses will be kept completely confidential.

* Required

DEMOGRAPHICS

This section will collect some information about you as a study participant.

1) Gender: *

o Male
o Female
o Not Listed
o Prefer not to say

2) Age Range: *

0 <30
0 30-35
0 36-40
0 41-45
0 46-50
0 >50
0 Prefer not to say

3) Number of years teaching: *

o 0-5
o 6-10
o 11-15
o 16-20
o >20

4) Primary grade level you teach: *

o K-6
o 7-12
o K-12, Specials Teacher (Art, Music, Health/PE, STEAM, Library, Family Consumer)

5) Primary teaching assignment: *

o K-6, Reading/ELA, Math, Science, or Social Studies
o K-6, Special Education/Title
o 7-12, ELA
o 7-12, Math
o 7-12, Science (+AFROTC)
o 7-12, Social Studies

o 7-12, Special Education
o K-12, Specials Teacher (Art, Music, Health/PE, STEAM, Library, Family Consumer)

TEACHER PERCEPTIONS OF TECHNOLOGY USE

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies. That is, the digital tools we use such as computers, laptops, tablets, interactive whiteboards, software programs, etc. Please answer all the questions. If you are uncertain of or neutral about your response, you may select "Neither Agree or Disagree."

6) Do you teach multiple primary subjects in grades K-6?
(e.g., reading, math, science, or social studies) *

o Yes
o No

7) K-6 Primary Subject Teacher Perceptions of the Effectiveness of 1:1 Technology *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Students use technology in my classroom for learning every day.	o	o	o	o	o
During lessons that involve student PC use, student engagement is high.	o	o	o	o	o
Student learning is enhanced by PC devices in my classroom.	o	o	o	o	o
The 1:1 PC device initiative is effective for **ELA**.	o	o	o	o	o
The 1:1 PC device initiative is effective for **Math**.	o	o	o	o	o

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
The 1:1 PC device initiative is effective for **Science**.	o	o	o	o	o
The 1:1 PC device initiative is effective for **Social Studies**.	o	o	o	o	o
The 1:1 PC device initiative is effective for my **grade level**.	o	o	o	o	o

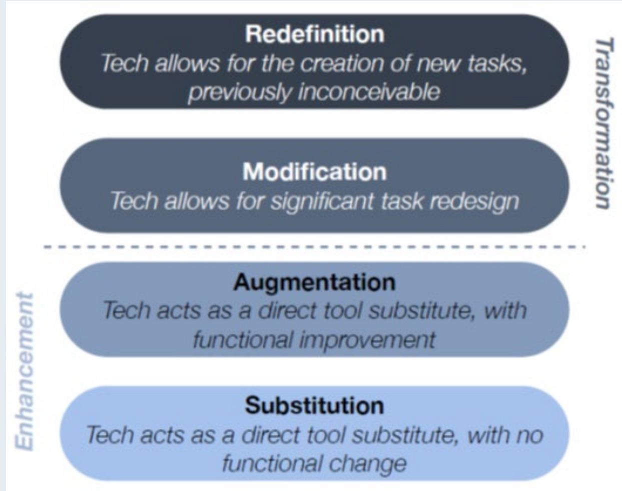
7) Teacher Perceptions of the Effectiveness of 1:1 Technology *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Students use technology in my classroom for learning every day.	o	o	o	o	o
During lessons that involve student PC use, student engagement is high.	o	o	o	o	o
Student learning is enhanced by PC devices in my classroom.	o	o	o	o	o
The 1:1 PC device initiative is effective for my subject area	o	o	o	o	o
The 1:1 PC device initiative is effective for my **grade level**.	o	o	o	o	o

8) Teacher Perceptions of Professional Development *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I have received professional development on teaching with PC devices in a 1:1 environment.	o	o	o	o	o
The professional development I received on teaching in a 1:1 PC environment was effective.	o	o	o	o	o
The Technology Integrators are an effective support or resource.	o	o	o	o	o
I utilize the Technology Integrators regularly.	o	o	o	o	o

SAMR



Technology use in learning can be categorized into a researched-based model consisting of four levels of integration: **S**ubstitution, **A**ugmentation, **M**odification, and **R**edefinition **(SAMR)**. Please consider each defined level of use and the examples provided to self-assess the use of technology in your classroom.

9) Substitution *

Substitution is the simplest form of educational technology use. It involves directly substituting technology for traditional practices.

Examples:

- Having students type their work instead of handwriting it.
- Using online quizzes and programs instead of pen and paper.
- Uploading a worksheet in PDF for student access, as opposed to photocopying.
- Using a digital interactive whiteboard as opposed to a traditional whiteboard and saving the results as a document.

	Always	Often	Sometimes	Rarely	Never
Substitution occurs in my classroom:	o	o	o	o	o

10) Augmentation *

At the Augmentation level, technology begins to enhance learning by making it more engaging than traditional instruction methods.

Examples:

- Students give oral presentations accompanied by a PowerPoint containing multimedia elements.
- Students use the internet to independently research a topic, as opposed to relying on teacher input.
- Teacher instruction is supplemented with a video that clarifies a particularly hard to explain concept.

	Always	Often	Sometimes	Rarely	Never
Augmentation occurs in my classroom:	o	o	o	o	o

11) Modification *

At the modification level, technology is integrated into instruction that transforms learning tasks beyond what is possible with traditional methods.

Examples:

- Students produce podcasts summarizing a topic, which can then be accessed by other students.
- Students create an informative video presentation in place of a standard oral presentation incorporating multimedia tools.
- Students create an informative video presentation in place of a standard oral presentation incorporating multimedia tools.

	Always	Often	Sometimes	Rarely	Never
Modification occurs in my classroom:	o	o	o	o	o

12) Redefinition *

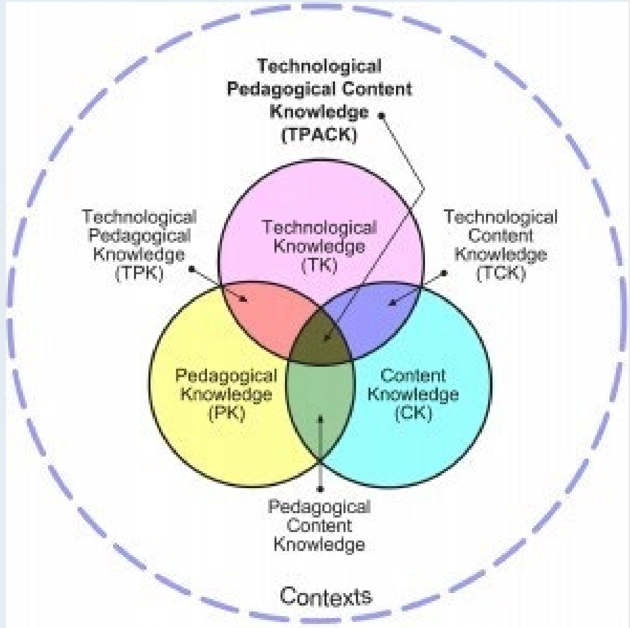
Redefinition is the most sophisticated level of technology use in the SAMR model. At this level, technology is used to create new learning activities that would not otherwise be possible.

Examples:

- Having students publish their work online where it can be viewed by peers and/or the broader community.
- Recording students as they deliver a presentation or practice a physical skill, then using this recording to prompt student reflection.
- Experimenting with tasks that uses extensive multimodal elements (e.g., producing documentaries or short films, webpages, print documents with complicated/creative layouts and graphics).

	Always	Often	Sometimes	Rarely	Never
Redefinition occurs in my classroom:	o	o	o	o	o

TPACK



TPACK stands for **T**echnology, **P**edagogy, **A**nd **C**ontent **K**nowledge. TPACK is a researched-based model for assessing and categorizing instructional technology understanding.

When teaching without technology, there are two primary areas of expertise involved, **Pedagogy** and **Content Knowledge**. These are both independent bodies of knowledge that "overlap" when you deliver instruction.

When teaching with technology, a third primary area of knowledge is introduced, **Technology**. The TPACK diagram above shows that teaching with technology overlaps in several ways with **Pedagogy** and **Content Knowledge**. At the center of the diagram, all three components come together in lessons that involve highly integrated instructional Technology, Pedagogy, and Content Knowledge.

It may help if you think of the center of the TPACK diagram as lessons that can be classified as **Modification** or **Redefinition** in the **SAMR** model.

The following questions will ask you to self-assess your knowledge of Technology itself, in addition to areas where Technology, Pedagogy, and Content Knowledge overlap such as Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and finally the combination of all three areas (TPACK).

13) TK (Technology Knowledge) *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I know how to solve my own technical problems.	o	o	o	o	o
I can learn technology easily.	o	o	o	o	o
I keep up with important new technologies.	o	o	o	o	o
I frequently play around with new technology.	o	o	o	o	o
I am familiar with a variety of technologies.	o	o	o	o	o
I have the technical skills I need to use technology.	o	o	o	o	o

14) TCK (Technology Content Knowledge) *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I am familiar with technologies that I can use for teaching and learning in my subject area(s).	o	o	o	o	o
I keep up with new technologies specific to teaching my subject area(s).	o	o	o	o	o
I use multiple forms of technology while teaching my subject area(s).	o	o	o	o	o

15) TPK (Technological Pedagogical Knowledge) *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I can choose technologies that enhance the teaching approaches for a lesson.	o	o	o	o	o
I can choose technologies that enhance students' learning for a lesson.	o	o	o	o	o
I am thinking critically about how to use technology in my classroom.	o	o	o	o	o
I can adapt the use of technologies that I learn about to different teaching activities.	o	o	o	o	o
I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.	o	o	o	o	o
I can use strategies that combine technology and teaching approaches in my classroom.	o	o	o	o	o
I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district.	o	o	o	o	o
I can choose technologies that enhance the content for a lesson.	o	o	o	o	o

16) TPACK (Technology Pedagogy and Content Knowledge) *

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I can teach lessons that effectively combine my content area knowledge, technologies, and teaching approaches.	o	o	o	o	o
I design lessons that fully integrate technology with lesson activities and subject matter.	o	o	o	o	o
I teach lessons that integrate technology into assessment of student content knowledge.	o	o	o	o	o

Open Ended Responses *

Please reflect on the 1:1 student computer initiative and how increased access and use of technology for teaching and learning has impacted your classroom.

17) What do you feel are the benefits of every student having a PC device?

18) What are the challenges to integrating technology into teaching and learning?

19) What professional development would support you with technology integration?

Thank you for your assistance with this survey, I really appreciate your participation and professional input. If you have any questions regarding this survey, please contact me: Ken Berlin, California University of Pennsylvania: BER3520@calu.edu

Appendix D

WASD Research Approval

WATTSBURG AREA
SCHOOL DISTRICT
STUDENT CENTERED · FUTURE FOCUSED

10782 Wattsburg Road
Erie, PA 16509
P (814) 824-3400
F (814) 824-5200
www.wattsburg.org

Mrs. Rebecca Kelley
Assistant to the Superintendent

Mr. Kenneth Berlin
Superintendent

Mrs. Vicki Bendig
Business Administrator

09/21/2021

Kenneth A. Berlin
10782 Wattsburg Road
Erie, PA 16509

Dear Ken:

The Wattsburg Area School District Board of Directors are pleased to offer this letter in support of your doctoral capstone project entitled, "Analysis of a One-to-One Technology Initiative: Examining Implementation at the Elementary and Secondary Levels." The proposed research has significant value for the Wattsburg Area School District as the District has invested a significant amount of capital into technology devices for staff and students. Having a better understanding of how and how often the technology is being used will help the District improve its integration of technology into a 21st century education for our students.

We have reviewed the project proposal and understand the following related to participation:

- Teacher participation involves completion of a survey.
- Participation will be voluntary, and teachers may withdraw from the study at any time.
- Data collected will be kept confidential and kept secure via electronic files.
- Potential risks are minimal, if any.

At its regular meeting on 09/20/2021, the Board unanimously voted to approve your research project in the District.

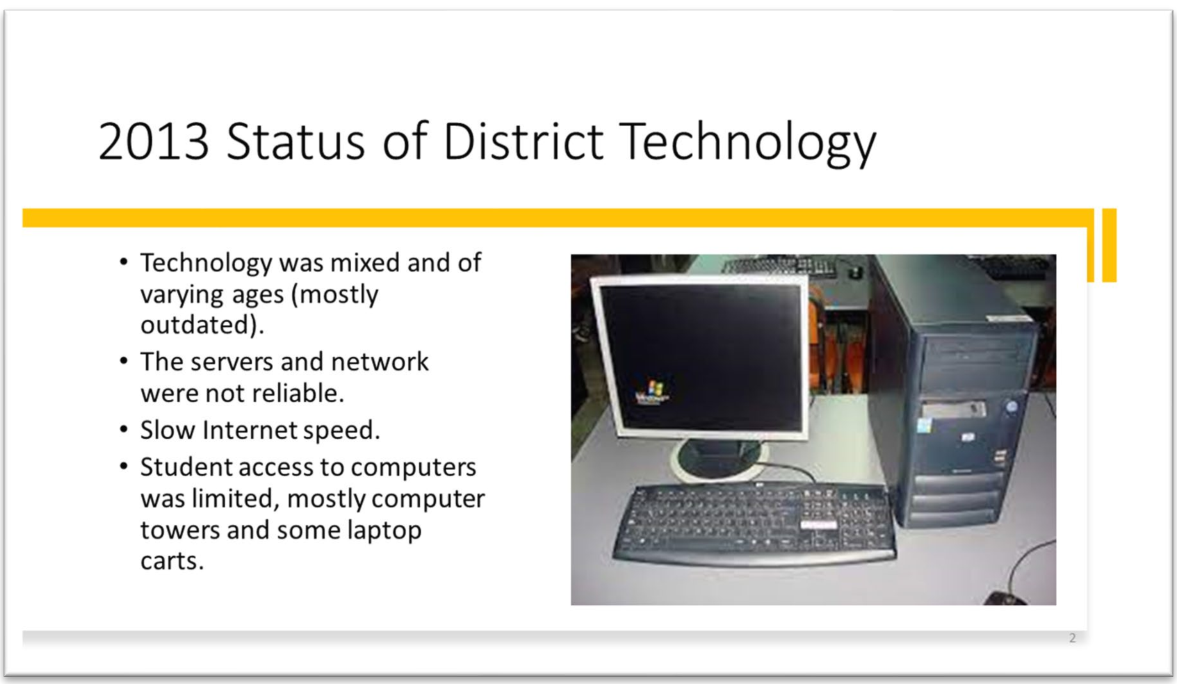
Please accept this letter as our formal consent and support of the District's participation in the proposed research project.

Sincerely,

Vicki Bendig
Board Secretary

Appendix E

Technology Survey Faculty Presentation



Plan: 2013-2019

- Six-Year Initiative to go 1:1 Student/Computer
- Stopgap Measure: Virtual PC Lab Thin-Client Project
- Significant network and server upgrades
- Upgraded Internet band-width and capacity
- Laptops, carts, & leases → Three-year lease cycle for all PC devices

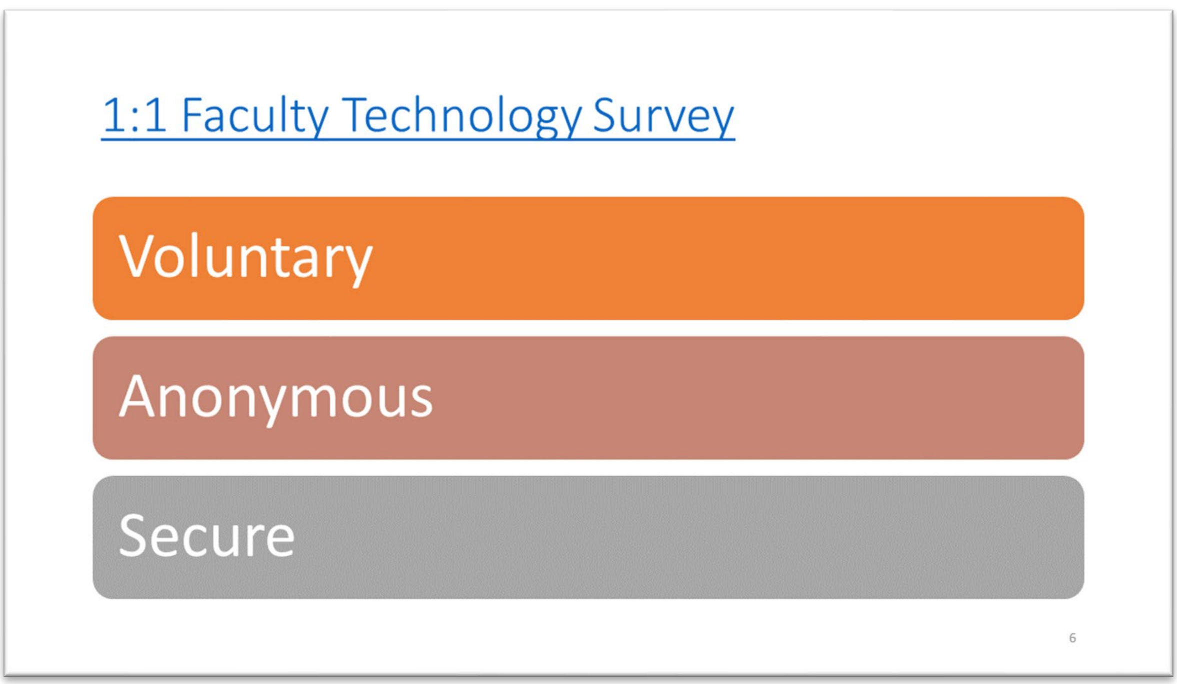
3

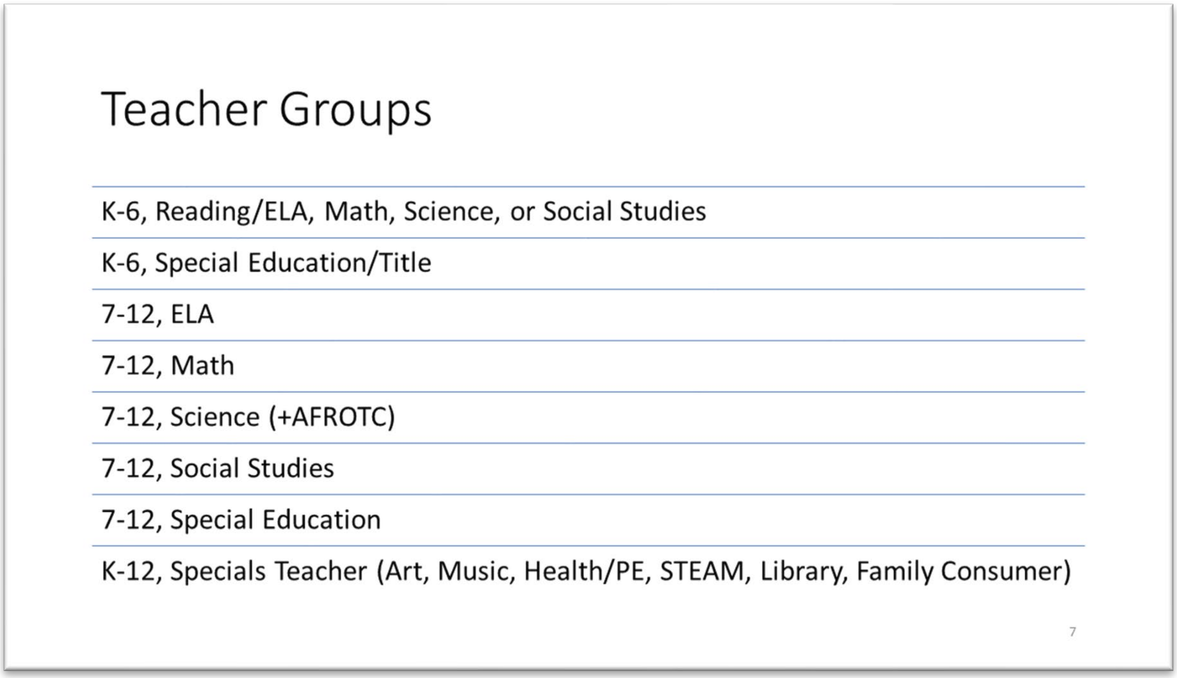
ANALYSIS OF 1:1 TECHNOLOGY INITIATIVE

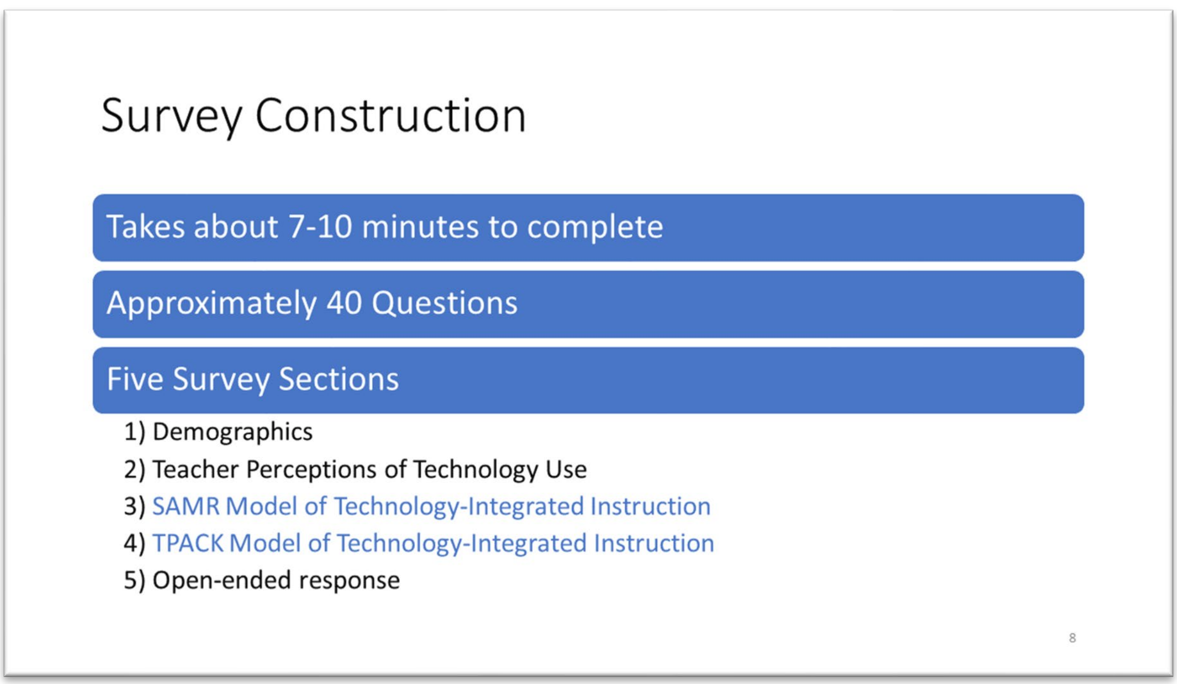
- Doctoral Capstone Research Project
- Approved by the WASD School Board
- Teachers' perceptions of the 1:1 computer initiative

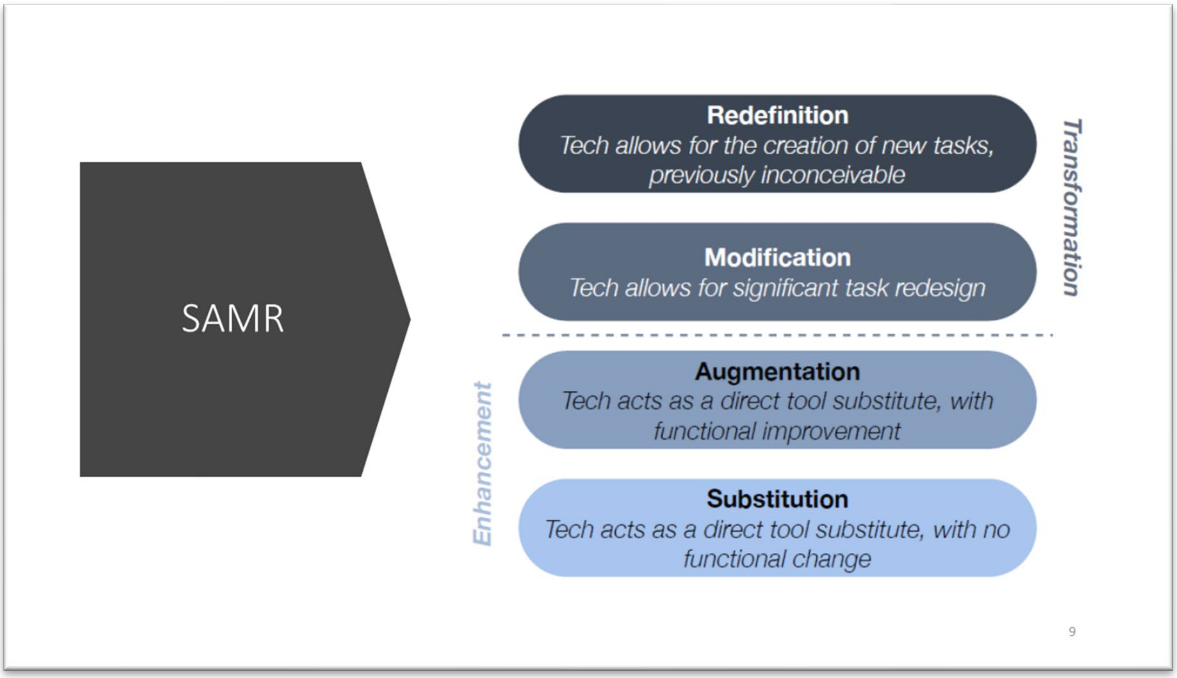
4

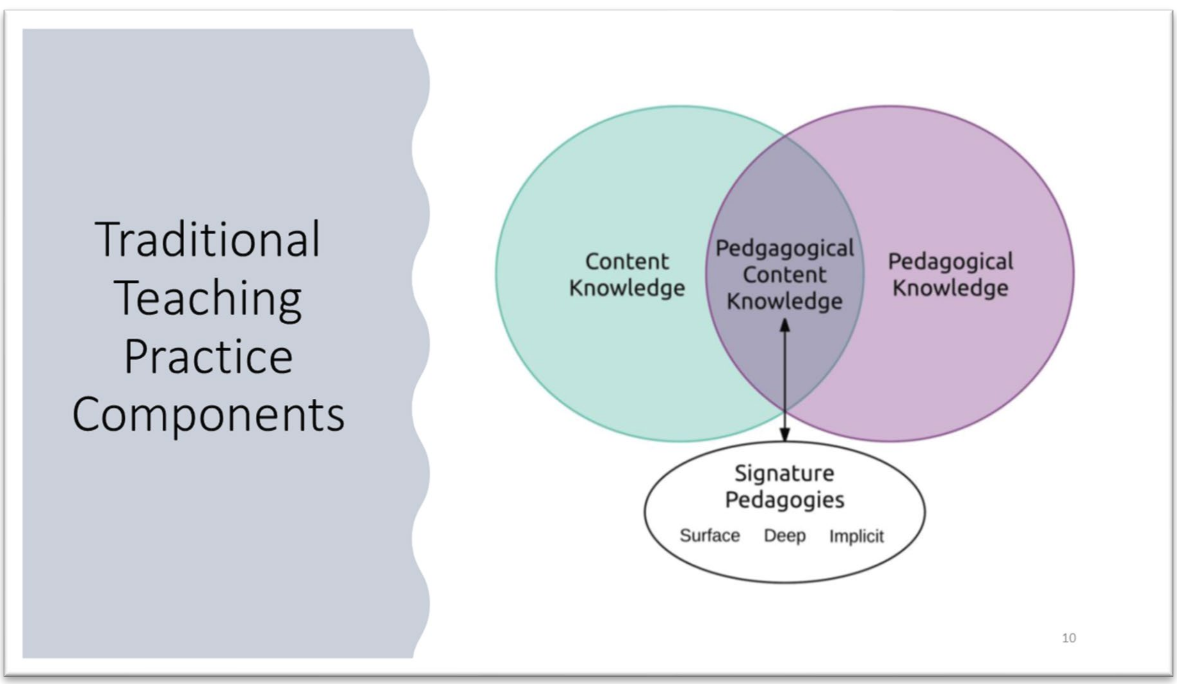

Research Questions
What are the teacher perceptions of the effectiveness of instruction in a 1:1 PC device environment?
How often and to what extent is 1:1 technology integrated into instruction?
What are the strengths and weaknesses of technology integrated teaching and learning?
What professional development is needed to support technology integrated instruction?
5

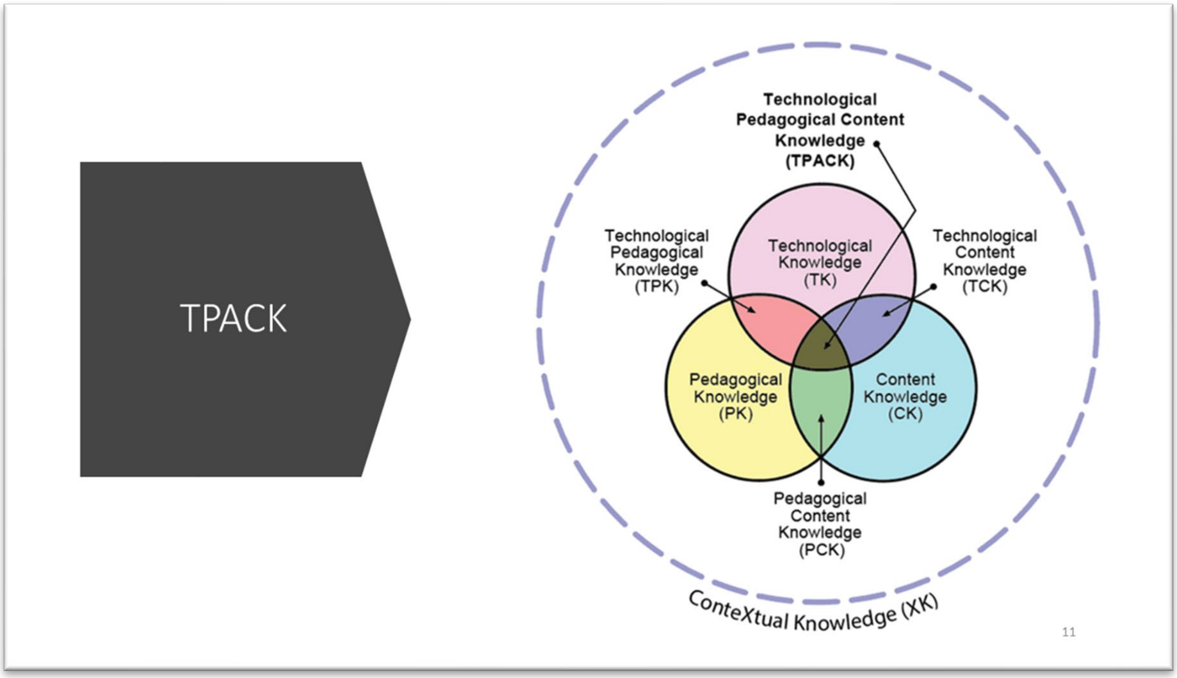

1:1 Faculty Technology Survey
Voluntary
Anonymous
Secure
6

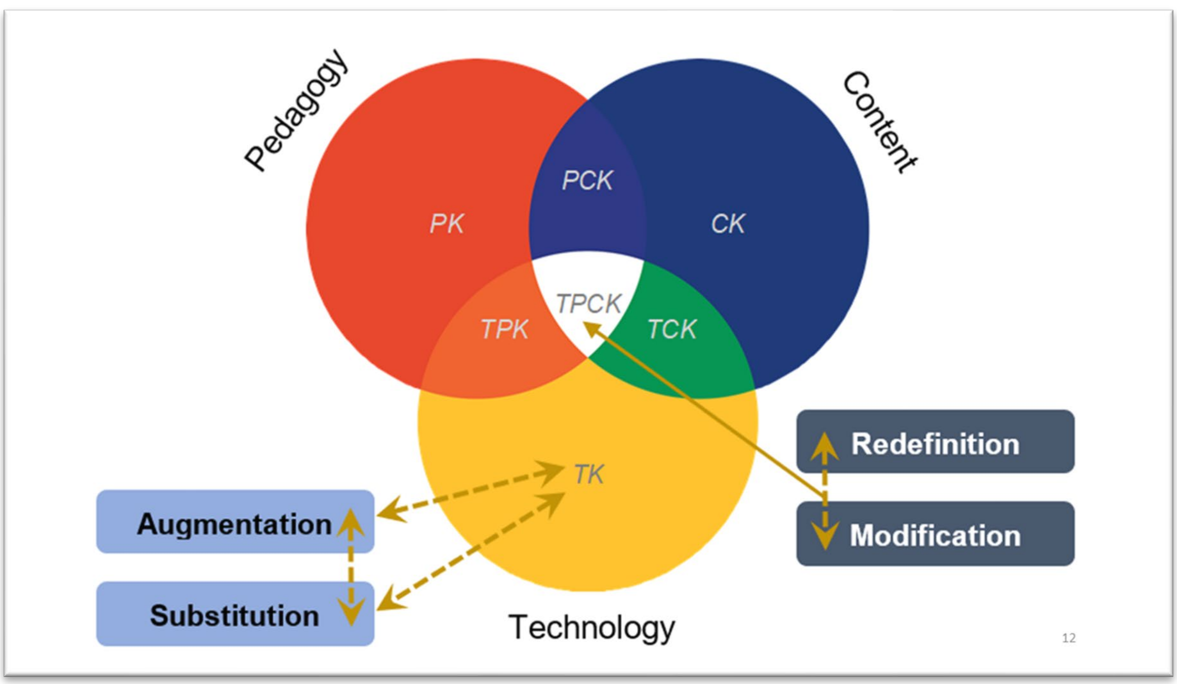

Teacher Groups
K-6, Reading/ELA, Math, Science, or Social Studies
K-6, Special Education/Title
7-12, ELA
7-12, Math
7-12, Science (+AFROTC)
7-12, Social Studies
7-12, Special Education
K-12, Specials Teacher (Art, Music, Health/PE, STEAM, Library, Family Consumer)
7


Survey Construction
Takes about 7-10 minutes to complete
Approximately 40 Questions
Five Survey Sections
1) Demographics
2) Teacher Perceptions of Technology Use
3) SAMR Model of Technology-Integrated Instruction
4) TPACK Model of Technology-Integrated Instruction
5) Open-ended response
8


SAMR
Redefinition
Tech allows for the creation of new tasks, previously inconceivable
Modification
Tech allows for significant task redesign
Transformation
Augmentation
Tech acts as a direct tool substitute, with functional improvement
Substitution
Tech acts as a direct tool substitute, with no functional change
Enhancement
9


Traditional Teaching Practice Components
Content Knowledge
Pedgagogical Content Knowledge
Pedagogical Knowledge
Signature Pedagogies
Surface
Deep
Implicit
10


TPACK
Technological Pedagogical Content Knowledge (TPACK)
Technological Pedagogical Knowledge (TPK)
Technological Knowledge (TK)
Technological Content Knowledge (TCK)
Pedagogical Knowledge (PK)
Content Knowledge (CK)
Pedagogical Content Knowledge (PCK)
ConteXtual Knowledge (XK)
11


Pedagogy
Content
PCK
PK
CK
TPCK
TPK
TCK
TK
Redefinition
Modification
Augmentation
Substitution
Technology
12

Appendix F

TPACK Survey Use Permission

From: Crawford, Denise A [SOE]
To: Berlin, Ken
Subject: Re: TPACK Survey Use Permission
Date: Tuesday, June 15, 2021 9:50:17 AM

Hi Ken,
Thank you for your interest in our TPACK survey. You have our permission to use all or part of the survey for your action research project.

Good luck!
Denise Crawford

Denise A. Schmidt-Crawford
Professor
Director, Center for Technology in Learning and Teaching
School of Education
Iowa State University
0624A Lagomarcino Hall
515.294.9141
dschmidt@iastate.edu
@SchmidtCrawford

President, Iowa Association of Colleges for Teacher Education (IACTE)
Past- President, Society for Information Technology and Teacher Education (SITE)
Apple Distinguished Educator (2003)

From: "Berlin, Ken" <Ken.Berlin@wattsburg.org>
Date: Monday, June 14, 2021 at 4:18 PM
To: "Crawford, Denise A [SOE]" <dschmidt@iastate.edu>
Subject: TPACK Survey Use Permission

Dr. Schmidt,

I am currently working on my doctorate at California University of PA. I am conducting action research in my school district regarding the efficacy of our initiative to integrate one-to-one technology use into instruction.

Attached is a brief overview my proposal, which has not been submitted for approval yet. I would like permission to adapt and use some of the TPACK survey questions and use them in my research.

Thanks for your consideration.

Regards,
Ken

Kenneth A. Berlin | Superintendent
WATTSBURG AREA SCHOOL DISTRICT
10782 Wattsburg Road | Erie, PA 16509
(814) 824-3400 ext. 4515
ken.berlin@wattsburg.org

Appendix G

Qualitative Data Codebook

Table G1

What do you feel are the benefits of every student having a PC device?

Code
Absent Schoolwork Completion
Differentiation of Instruction
Ease of Access to Technology and Information
Extended Learning Opportunities
Increased Student Engagement
Increased Student/Teacher Communication
Increased Teaching Options
Preparing Students for Technology Workplace

Note: This open-ended question collected qualitative data for Research Question Three.

Table G2

What are the challenges to integrating technology into teaching and learning?

Code
Adequate Student Tech Knowledge
Adequate Teacher Tech Knowledge
Battery Life/Not Charged
Integration With Subject Matter
Keeping Students On-Task
Student Forgot Computer/Charger
Student Home Internet Connectivity
Tech Problems (Wi-Fi, Device, Applications, etc.)
Time (Learn, Collaborate, Set-Up, etc.)

Note: This open-ended question collected qualitative data for Research Question Three.

Table G3

What professional development would support you with technology integration?

Code
Collaboration Time (PLC)
Differentiated
Integration Strategies
Ongoing/New Technology
Specific Technology Training Request
Subject Specific Technology

Note: This open-ended question collected qualitative data for Research Question Four.