Facilities Infrastructure Needs and Practices to Support Technology Implementation in Two Rural School Divisions in Virginia

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ABSTRACT

The purpose of this study was to determine the planning and implementation practices necessary for facilities infrastructure to support technology initiatives in two rural school divisions in Virginia. The research questions guiding this study were: (1) What short-term and/or long-term plans are put in place for building and maintaining facilities infrastructure to support technology initiatives? (2) What physical components, equipment, and personnel are necessary for adequate facilities infrastructure to support technology initiatives? (3) What are the perceived infrastructure barriers to effective integration of technology in a school building? This qualitative study was designed based on a case study approach (Merriam & Tisdale, 2015).

This qualitative study used purposeful sampling. The interview participants selected for this study were division-level technology leaders and their technology staff. The participants taking part in this purposeful sampling were at various stages of their profession, and at differing years of service, within their respective school divisions. The findings of this study may help division superintendents and division-wide technology leaders make more informed decisions regarding school facilities infrastructure needs to support technology initiatives. The findings from this study indicate there is no consensus for how to build and maintain school facilities infrastructure to support technology initiatives. However, there are numerous commonalities in barriers to successful implementation of technology initiatives. Findings also uncovered common themes for best practice in how to plan and implement for facilities infrastructure to support technology initiatives.

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GENERAL AUDIENCE ABSTRACT

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DEDICATION

The completion of this doctoral program has been an eye opening and fulfilling journey. As I worked on my undergraduate and master degrees, I would have never envisioned being at the place I am today, and yet, and I am all the more grateful for it. To my wife, Stephanie, I cannot express how thankful I am for the sacrifices you made caring for Austin, and then Abby, during the days and evenings I spent in class and in the library. To my parents, Jerry and Melissa, thank you for always loving me unconditionally and helping to mold and shape me into the person I am today. To my second parents, James and Debbie, thank you for always being supportive of Stephanie and our family. Austin and Abby, I hope as you continue to get older, you will not take for granted any opportunity you have to learn and grow as a person. Knowledge is a special gift, one that no one can take from you, and one that can have endless possibilities to help others in the world around you.

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CHAPTER ONE

BACKGROUND OF THE STUDY

During the past several decades, the distribution of state and local funds spent on school facilities and infrastructure in the United States has created widespread concern regarding the conditions of public schools (Brunner & Rueben, 2001; Plummer, 2006). According to Plummer (2006), school facilities in the United States are funded overwhelmingly by local property taxes; however, the amount of funding from the federal government has increased over the last decade. Temin (2010) suggested that the expansion of the federal role in school facility funding has been seen as an effort to stimulate local economies through school renovation and construction. Accordingly, the American Recovery and Reinvestment Act of 2009 (ARRA) allocated $11 billion during the 2009 and 2010 school years for qualified school construction bonds (QSCBs) for U.S. public schools (Ingle, Bowers, & Davis, 2014).

Despite this influx of federal funding for facilities, considerable disparities exist across school divisions regarding their capacity for school infrastructure funding. Some states provide noticeably less financial funding for capital investment than for operating expenses (Sielke, 2001). Several reports (NCES, 2000; USGAO, 1995) have identified substantial and growing facility needs for public schools across the nation. Declining physical conditions of U.S. public schools and insufficient funds to address those conditions has led to many divisions electing to defer maintenance over multiple years. Deferred maintenance has contributed to the deterioration of buildings, and as costs escalate accordingly, has further eroded the nation's investment in public school facilities.

In addition to funding issues for school facilities, the age of many public school buildings in the U.S. is a major factor in infrastructure inadequacy. Several studies (Hansen, 1992; Rowand, 1999) indicated that public school buildings in the United States have an average age of 42 years. The average age of school buildings in the northeast and central states is 46 years while the average of those in the southeast is 37. Many of America's schools require frequent repairs.

> About one-fourth (28 percent) of all public schools were built before 1950, and 45 percent of all public schools were built between 1950 and 1969 (see table 1). Seventeen percent of public schools were built between 1970 and 1984, and 10 percent were built after 1985. The increase in the construction of schools between 1950 and 1969

corresponds to the years during which the Baby Boom generation was going to school (NCES, 1999, para. 4).

According to Ornstein (1994), schools 20 to 30 years old regularly require replacement of equipment. By the time a building is 30 to 40 years old, the original equipment, including the roof and electrical systems, should have been replaced. After 40 years, a school building enters a phase of rapid deterioration. When schools are 60 years old, most enter a state of abandonment. With many aging public school buildings, investments in technology infrastructure have been necessary. Public school technology initiatives have progressed from stand-alone computer labs, to computers in the classroom, then portable laptop carts, and now one-to-one laptop initiatives (Bonifaz & Zucker, 2004). In 2003, individual public school divisions in the U.S. spent between $218 and $233 million on hardware and software additions and/or upgrades (Fickes, 2004). However, not all public school divisions have developed appropriate infrastructure needed to support technology initiatives. One survey respondent from the USGAO (1995) survey stated, "our school facilities are not energy efficient or wired for modern technology" (p. 18).

Statement of the Problem

This study focused on three major problems. The first is the constantly changing nature of technology. The second is a lack of consensus in how to plan for and develop technology within a school division. The third problem is aging and outdated school facilities in many school divisions. "A well designed learning environment takes into consideration the essentials of the learning process and the latest technological development" (Chan, 1996, p. 17). However, public school buildings in the United States have an average age of 42 years (Rowand, 1999). According to Chan (1996), educational facility research reveals the obsolete conditions of school buildings are due to old school buildings needing educational program updates. Information and Communications Technology (ICT) infrastructure is the observed accessibility and appropriateness of ICT components such as hardware, software, and outlying equipment maintained by the school (Vanderlinde & Van Braak, 2010). ICT infrastructure also encompasses a school's access to the Internet and other ancillary resources tied to technology use (Pelgrum, 2001).

"Most previous studies have mainly focused on the benefits brought by a single type of facility or equipment for learning and teaching. However, relatively fewer studies have been conducted to explore the relationship between the infrastructure and application of ICT in developing areas or even depressed areas on a nationwide scale" (Lu, Tsai, & Wu, 2015). "Ever since the advent of the personal computer in the 1980s, information and communication technology (ICT) has increasingly entered the sphere of education in both developed and developing countries" (Judge, 2013, p. 309). Researchers (Chan, 1996; Hansen, 1992; Lu et al., 2015; Pelgrum, 2001; Rowand, 1999; Vanderlinde & Van Braak, 2010) have outlined how a problem exists, as older school buildings are a challenge to build and maintain ICT infrastructure, especially as school buildings are aging.

Purpose of the Study

The purpose of this study was to determine the planning and implementation practices necessary for facilities infrastructure to support technology initiatives in two rural school divisions in Virginia. Research in the field of school facilities infrastructure to support technology initiatives indicates there is no consensus for how to build infrastructure to support technology initiatives (Arnold, 2014; Lu et al., 2015; Vidoni, 2004). Due to the rapidly changing pace of information technology (IT) systems, it is difficult to implement and maintain all of the features that a new IT system represents (Austin, 2005). According to Sparks (2006), the rapid rate of increasing sophistication with technology devices demand that the supporting infrastructure be adaptable. When considering facility construction, designers must account for their current technology needs in addition to developing a facility capable of supporting any new changes or initiatives in the next five to ten years (Sparks, 2006).

Significance of the Study

Keirl (2015) stated that technology is a part of virtually every aspect of daily life as "humans cannot 'be' without technology and technology 'is' by human intention and (inter)action. That is, technologies and humans co-exist intimately" (p. 14). American public schools are no exception. "In this 'knowledge age', where knowledge is the 'new currency', students require skills to access, analyze and evaluate information that is constantly changing, and use—and contribute to—this changing information, in collaboration with others, in order to support decision making, development and innovation" (Buntting, Williams, & Jones, 2015, p. 1).

School divisions have attempted to keep up with the constant wave of technological innovation by infusing these technologies into the curriculum and structure of education. In order to be able to continually maintain and improve these innovations, schools must develop the appropriate technological infrastructure to sustain such initiatives (Keller & Bichelmeyer, 2004; Leutscher, 2005). This study's findings will enable division leaders to better understand the needs to develop and maintain facilities infrastructure to support technology initiatives within their rural school divisions.

Conceptual Framework

The conceptual framework for this study was developed through a review of literature and is a depiction of the potential track that results in the appropriate planning and components necessary to successfully build facilities infrastructure to support technology initiatives in the classroom. This conceptual framework was based on planning for technology initiatives, the types of equipment and hardware/software utilized to support technology initiatives in the classroom, the personnel and professional development training for technology personnel to build and maintain technology infrastructure, and perceived barriers to technology infrastructure.

Identifying the barriers to technology integration through the lens of facilities infrastructure needs provide opportunities for school and technology leaders to aid in the reduction of these barriers. Thus, this process could result in an increase in consistent technology integration within the classroom. Based upon this framework, this study examined the perceptions of K-12 public school technology leaders and their staff regarding technology infrastructure integration needs, priorities, and identifiable barriers that interfere with technology infrastructure integration in rural public school divisions in Virginia.

The hypotheses guiding this study were: 1) the age of the building impacts the capability of its infrastructure to support technology and 2) school and technology leaders recognize identifiable infrastructure barriers that interfere with consistent technology integration. As a result of these infrastructure barriers, technology is not integrated into the classroom on a consistent basis, which creates a technology gap between the school division's vision for technology use and its capacity for actual technology use. When this is factored in with an aging school building, the result is inadequate building infrastructure to support technology initiatives.

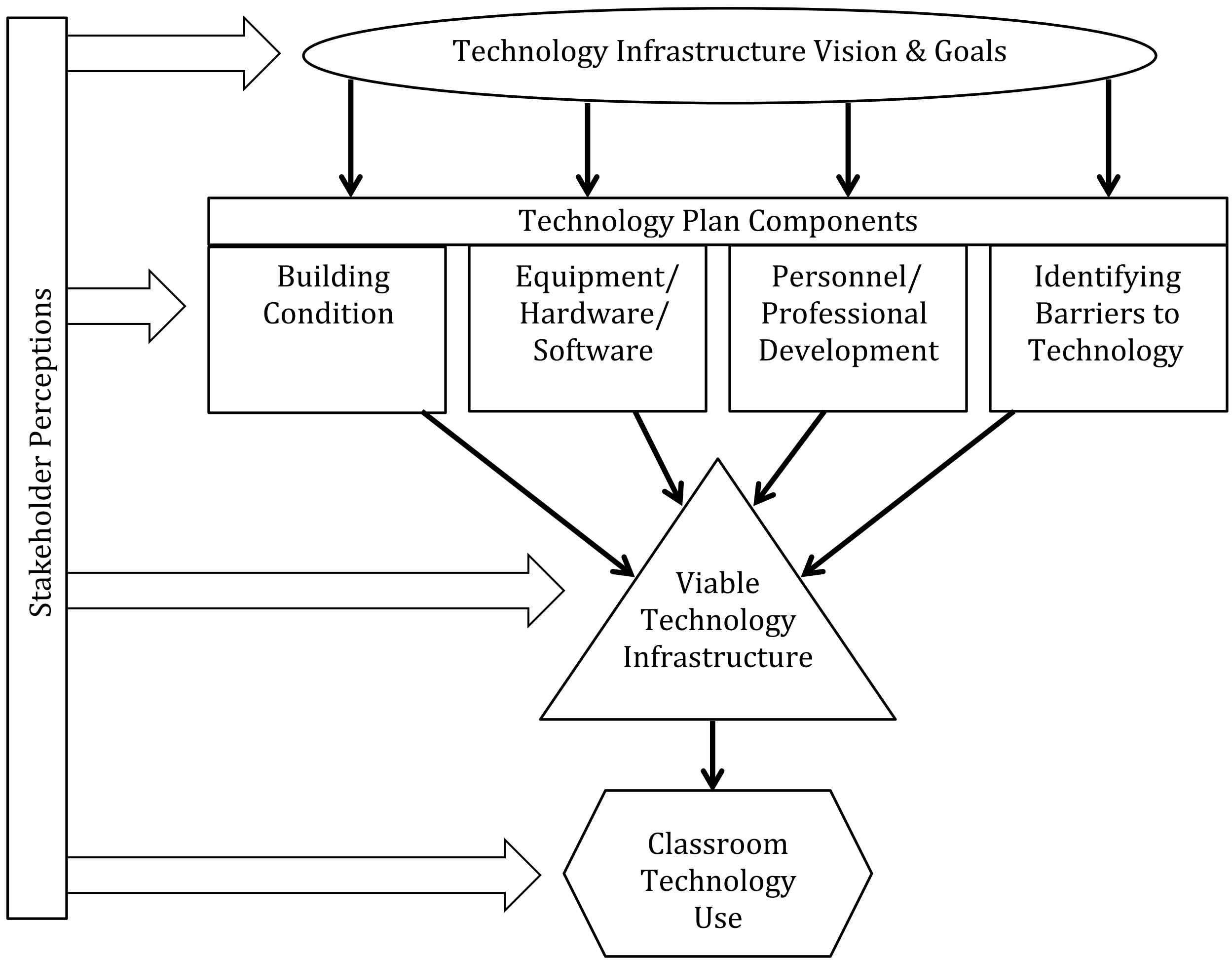

Figure 1. School infrastructure to support technology conceptual framework.

Research Questions

This study investigated three research questions:

1. What short-term and/or long-term plans are put in place for building and maintaining facilities infrastructure to support technology initiatives?
2. What physical components, equipment, and personnel are necessary for adequate facility infrastructure to support technology initiatives?
3. What are the perceived infrastructure barriers to effective integration of technology in a school building?

Limitations

In this qualitative study, the analyses were based upon self-reported information. Therefore, it is possible the participants did not fully disclose all pertinent information pertaining to this study. However, it was the focus of this study to investigate school and technology leaders' perceptions of facilities infrastructure needs to support technology integration and identify any barriers they believed would limit the integration of technology into the classroom. Additionally, the researcher's assumption that all participants believed that there were barriers to technology infrastructure, to some degree, may have been limiting, as not all the participants may have shared the same view.

Delimitations

This qualitative study examined school and technology leaders' perceptions and beliefs regarding the needs for technology infrastructure integration and barriers that may exist. With this in mind, the delimitations of this study included the utilization of purposeful sampling and did not take into consideration a larger number of school divisions to participate in the study. The population for this study was representative of rural public school divisions in Virginia and may not be representative of public school divisions in other states. This study also only focused on rural public school divisions and did not take into account suburban or urban public schools, religious or non-religious private schools, and charter schools.

Definition of Terms

The following terms are all concepts central to the research in this dissertation. They include a broad cross-section of definitions regarding school technology and infrastructure.

Digital Divide*.* The gap between the privileged and underprivileged members of society in terms of ability to access digital tools and the Internet (Chen, 2015).

Information and Communications Technology (ICT). An umbrella term for all of the various media employed in communicating information. In an educational context, ICT may include computers, the Internet, and other digital mediums (Chandler, 2016).

Instructional Technology Resource Teacher (ITRT). Mainly responsible for computer software and to work with teachers to implement technology in the classroom (Coffman, 2009).

Organizational Infrastructure. Services and foundations including planning, equipment acquisition, technical support, policies, procedures, training, standard usage, accountability, and maintenance (Norman, 1998).

Rural School Divisions. Any school division whose school board office is not located in a city center or metropolitan area based on National Center for Education Statistics data (Yax, 2002).

Technology Infrastructure. Hardware and software, such as a school's network, servers, computers, computer components such as the motherboard or central processing unit, software, audio-visual devices, etc. (Leutscher, 2005). Also see: IT Infrastructure.

Technology Support Staff Person. Responsible for the hardware and repair of broken devices and systems (Coffman, 2009).

Organization of the Study

This research study is organized into five chapters. Chapter one contains the background and introduction of the study, the statement of the problem, the significance, and purpose of the study. The conceptual framework used for this study is also introduced, as well as the three research questions. Also included are this study's limitations, delimitations, and definitions of terms that may not be common knowledge. Chapter two provides a review of the current literature surrounding the topic of school facilities infrastructure needs as it relates to supporting technology integration in the classroom. Chapter three contains a description of the research design and methodology used for this study. This chapter provides an overview of the study sample. Data collection procedures are shared along with the survey instrument used in this study. This chapter also explains how the collected data will be analyzed. In Chapter four, the data, or findings, are reported. Included is a profile of the participants and data analysis. Chapter five provides the study's results and findings. Possible implications of the findings regarding educational practice are discussed. This final chapter also includes recommendations for future research regarding school facilities infrastructure needs to support technology initiatives in the classroom.

CHAPTER TWO
REVIEW OF LITERATURE

Introduction

"Throughout the history of education, advances in technology are the impetus for new methods to assist in the delivery and provide summative evidence of student learning on a day to day, year by year basis" (Radke, 2011, p. 1). According to Windschitl and Sahl (2002), in recent years, the use of personal computing has been growing in school divisions around the United States. The implementation of one-to-one technology initiatives is growing rapidly throughout the United States (Bebell & O'Dwyer, 2010). As more school divisions take on the challenge of implementing some form of a device initiative, they must also tackle the issue of unmet funding needs for school infrastructure. This challenge is growing, according to Crampton, Thompson, and Hagey (2001), whose research indicated an unmet school infrastructure need of $266.1 billion, a total substantially larger than previous research indicated. This research examines school facilities infrastructure needs, specifically in rural school divisions, and how those divisions can develop a plan to meet their technology and infrastructure needs.

Search Procedure

The initial search for this review of literature utilized the following key terms: "American public schools facilities," "School facilities," "American public schools technology infrastructure," and "Rural schools." These key terms were cross-referenced in the Virginia Tech online library Summon search engine, Google Scholar, and the Education Resources Information Center (ERIC Database). The resulting topics were filtered by title and dissertation abstracts. Articles, dissertations, and books that were pertinent to this review of literature were selected. Research from these searches also utilized reference pages of the materials to include other viable research into this review of literature on school facilities and infrastructure as they pertain to technology initiatives. Over thirty dissertations and scholarly articles were selected from this initial search.

Brief History of American Education Technology

Educational media for instructional purposes can trace its origins back to the first decade of the 20th century (Saettler, 2004). According to Anderson, Finn, and Campion (1963), magic lanterns, used in some schools during the latter half of the 1800's, and the motion picture projector were the initial media devices introduced into schools. The post-World War II era brought a focus to audiovisual research in an effort to identify learning principles that could be used to develop educational audiovisual material (Reiser, 2001).

Computer programs, and especially personal computers, did not start to impact school infrastructure directly until the latter half of the 1900's (Campbell-Kelly, 2009). In 1964, educator John Kemeny and computer scientist Thomas E. Kurtz invented the computer program Beginner's All-purpose Symbolic Instruction Code (BASIC). BASIC allowed undergraduate students, even school-age children, to begin to write their own programs (Campbell-Kelly, 2009). "By the early 1970s, the terms educational technology and instructional technology began to replace audiovisual instruction to describe the application of media for instructional purposes" (Reiser, 2001, p. 59).

Widespread use of the computer began in the 1980's (Reiser, 2001). The International Business Machines (IBM) personal computer (PC) burst onto the scene, and by 1983, home computers represented over 50% of total PC sales (Cator, 2010). Also by 1983, computers were used for instructional education purposes in more than 40% of U.S. elementary schools and more than 75% of all U.S. secondary schools (Center for Social Organization of Schools, 1983). The first major one-to-one school computer program began in the 1980's with the Apple Classrooms of Tomorrow (ACOT) project. ACOT was the first large-scale K-12 public school initiative supporting one-to-one computer access for students and teachers (Donovan, Hartley, & Strudler 2007; Keefe & Zucker, 2003; Whiteside, 2013).

According to Gosmire and Grady (2007), the 1990's became a period of tremendous growth for the technology industry. Mobile technologies, virtual learning, and data systems became important technology trends for schools (Gosmire & Grady, 2007). In the early 1990's, school systems focused on creating an environment of technology-driven curriculum (Kennedy, 2008). More widespread integration of stand-alone computer labs in schools allowed students to access word processing and spreadsheet functions for project completion. The next technological advancement for many schools was the linking of computers together through the Internet (Kennedy, 2008). As the growth of the Internet and tech companies exploded throughout American businesses in the 1990's, American public schools sought to keep pace. In 1994, 3% of public school classrooms had access to the Internet. By 2005, 94% of all classrooms were connected (Kennedy, 2008). “The rationale for boosting the technology available in schools was educational improvement” (Kennedy, 2008, para. 8).

The importance of the field of education keeping pace with American society was defined by Levy and Murnane (2006) as advances in technology, focused on computerization, played a major role in changes within the workforce. Many jobs in the modern workforce involve the processing of information, requiring skillful thought, problem solving, and multifaceted communication. Diffusion and understanding of information, literacy and math skills, and communication are integral skills for learners in the 21st (Levy & Murnane, 2006). The last three decades have seen an increase in spending for the implementation of technology in school divisions (Maschmann, 2014). Funding from states and the federal government gave school leaders the opportunity to develop and expand classroom technology. The development of technology plans at the local, state, and national levels provided a context for legislators to direct large amounts of start-up funding for development of school infrastructure (Maschmann, 2014).

School Funding

School funding law. “Education is the largest share of state and local government budgets and a continuing concern of lawmakers, the courts, educators and the public” (Verstegen, 2011, p. 2). Changes in school finance have been relatively small dating back to the 1920’s. However, following two court cases involving school finance, *Serrano v. Priest* (1971) and *San Antonio v. Rodriguez* (1973), a flood of school-based finance reform ensued. At the end of the 1970’s, state courts were split over the issue. In seven states, high courts found state finance systems unconstitutional. In another 15 states, state finance systems were found constitutional. In 1983, *a Nation at Risk* was released. It foreshadowed a bleak outlook for our nation’s schools that could negatively impact society as a whole. Soon after the release of this work, education reform, previously focused only on school finance, evolved into a more comprehensive reform focused on goals, standards, and instructional-based needs. The American public appeared to worry more about instruction than finance and money (Maringa, 2013; Minorini & Sugarman, 1999; Verstegen, 2011).

According to Verstegen (2011), during the end of the 1980s, four state supreme courts finalized decisions that found their state’s finance system unconstitutional. These court decisions diverged from previous decisions and focused on adequacy. School finance reform now focused not just on dollars, but also on what those dollars bought (Verstegen, 2011). The 1990's brought a wind of change to court rulings regarding school finance. *McDuffy v. Secretary of the Executive Office of Education* (1993) held that the state has a "constitutionally enforceable duty to provide all public school students with an adequate education" (Verstegen, 2007, p. 305). Three days following this court decision the Education Reform Act (ERA) was signed into law. This law called for numerous changes to quality and accountability in education, including a fair and adequate education finance system (Verstegen, 2007).

Current funding model. In many states, this new system operated by distributing funding to public schools through an initial per pupil funding amount specified by the state (Verstegen, 2007). A determination was made by the state as to the minimum a city, town, or regional school district must contribute through the local property tax and other revenue sources. Typically, wealthy divisions with higher property or revenue values raised more local funding, while less affluent divisions with lower property values, and/or less ability for revenue growth, raised less local funding (Verstegen, 2007). The remaining balance above the specified amount was made up by the state. Local counties and cities could also supplement their funding through additional taxes not matched by the state (Verstegen, 2007).

Dickerson and Ackerman (2016) stated that since the start of the [2000's] recession, the funding for school facilities had declined. Twenty-six of fifty states provided less funding for the 2012- 2013 school year than for the year prior. Thirty-five of fifty states provided less funding in 2016 than 2008 funding levels. Funding dropped from $16.4 billion in 2008 to $10.3 billion in 2012. The American Society of Civil Engineers (2013) Report Card stated funding for school facilities dropped by 50% during this period. Since 1980, the federal investment in schools has typically been only 8%, while the states provide 48% and localities provide the other 44%. This facility funding issue occurred despite enrollment forecasts that showed student populations were predicted to grow over the next five years, with anticipated record enrollments during the second half of this decade. The American Society of Civil Engineers (2013) Report Card made several recommendations, including the need for systematic, comprehensive, and preventative maintenance programs, and a national data collection system for reporting of school facility conditions.

Rural school funding. Rural school divisions often have fewer community-based resources donated to them and heavily depend on government resource support (Schwartzbeck, 2003). When federal, state, or local governments cut educational funding, rural schools typically face worse outcomes than urban schools from these funding reductions. Comparatively, highly remote, rural schools face the greatest hardship of all (Bolinger, 1999; Katsinas & Moeck, 2002; Schwartzbeck, 2003; Silvis, 2000; Staihr & Sheaff, 2001; VanSciver, 1994).

Information and Communications Technology

"The role of new technologies in classroom instruction has been, and perhaps always will be, a contentious issue among educators, policy makers, and community leaders" (Leutscher, 2005, p. 14). Vidoni (2004) noted how even a decade ago, the price of building technology infrastructure into schools was a challenge. Leutscher (2005) focused on an organizational model, entitled the Comprehensive Assessment of School Technology (CAST), for evaluating organizational infrastructure. The model can help school leaders to facilitate the deployment of information and communication technology (ICT) and integrate it into practical application within schools (Leutscher, 2005). According to Chandler (2016), ICT is an overarching term for all types of media used in communicating information. In the field of education, ICT can include computers, the Internet, television broadcasts, and other digital or electronic mediums. ICT integration into schools has been ongoing since the 1990's (Leutscher, 2005). As a need for more funding for ICT resources has increased, the federal government and states have stepped up to support the funding needs of schools.

> In 2000 and 2001 the U.S. government committed more than $2 billion to fund the Universal Service Fund (e-Rate) program (U.S. Department of Education, 2000; Universal Service Administrative Company, 2003), which allows eligible schools and libraries to purchase computers and telecommunications equipment at a discount. However, the bulk of the money for developing and sustaining an effective school technology infrastructure comes from the communities that approve bonds and millages in local elections (Leutscher, 2005, p.3).

The President's Committee of Advisors on Science and Technology (PCAST) report (1997) recommended that 5% of all public K-12 school funding expenditures be dedicated to technology. It also stated these expenditures should not be through raising bonds, but instead show as continuing line items in the operating budgets of schools. However, state funds for K-12 education continue to remain below levels prior to the 2008 economic downturn (Brown &

Green, 2015). "Thirty-five states provided less funding on a per-student basis during the 2013–2014 than they did during the 2007–2008 school year" (Brown & Green, 2015, para. 25). A lower funding level of K–12 education is mainly due to: state tax revenues remaining below 2008 levels, rising costs, and a reduction in federal aid to states (Leachman & Mai, 2014).

Norman (1998) stated organizational infrastructure focuses on services and foundations including planning, equipment acquisition, technical support, policies, procedures, training, standard usage, accountability, and maintenance; however organizational infrastructure differs from technology infrastructure, which is

> the hardware and software that employees use to do their work. The school's network, servers, computers, components in the computers (for example, motherboard, central processing unit, CD drives, DVD drive, sound card), software, audio-visual devices, etc. comprise the technology infrastructure of the school" (Leutscher, 2005, p. 8). Kennewell, Parkinson, and Tanner (2002) confirmed Norman: "ICT capability requires not only technical knowledge and skills but an awareness of this knowledge base, so that effective choices can be made" (p. 18).

Barriers to information and communications technology. Savill-Smith (2005) stated that in order for a specific device to be used to its full potential, certain technical and organizational conditions must be satisfied. However, barriers exist for many schools between organizational infrastructure and ICT infrastructure (Leutscher, 2005). Many strategists require technology programs to demonstrate student achievement growth. However, many programs disallow the use of funds for ancillary items such as professional development training and support. Leutscher (2005) asserted that although many divisions and localities are adding new technological hardware, they are doing so in ways that do not always best support the growth of student achievement.

> This is a case of economical and technical considerations given greater weight than educational considerations in the decision-making process. This anecdote reveals that, while schools are acquiring and making equipment more available to students and teachers, effective educational use of the equipment may still face obstacles (Leutscher, 2005, p. 10-11).

Difficulties arise between organizational infrastructure and ICT infrastructure, as educational technology researchers often focus on model cases of technology adoption and implementation to demonstrate what is achievable and to outline steps for other organizations to replicate achieving the same success (Leutscher, 2005). This focus can create biases for policy makers, educational leaders, and even educational researchers to be unaware of the reality of ICT and overstate its progress in schools (Leutscher, 2005). Lu et al. (2015) concurred: “it is necessary to clarify the demands for ICT infrastructure in education based on the current development status to remedy the disparities of regional development and reduce excess investment” (p. 250).

Schools and divisions that do not have an effective organizational technology infrastructure to support their ICT initiatives can often create inefficient and ineffective technology usage within their buildings (Leutscher, 2005). In some school divisions, the use of technology is left to the individual classroom teachers. This practice may reveal short-term gains, but the long-term benefits for students in regards to ICT involve coordinated and well-planned roll out implementation of ICT across a school (Leutscher, 2005). Without a coordinated and consistent set of goals and objectives to be implemented across an entire school setting, the opportunity for conflicts and misunderstandings in using the ICT can be more widespread (Mora, 1995).

Meeks (2014) supported the idea of a structured set of goals and objects through a Learning and Teaching Roadmap. This strategic planning process should include seven silos (curriculum/instructional program, professional development, policies and processes, technical support, facilities, infrastructure, systems and components) to maximize the success of the initiative. “A Learning and Teaching Roadmap that leaves one silo out of the discussions and activities will reduce the potential success of the plan by 50 %. Leaving two of the silos out of the plan virtually assures the plan will never work” (Meeks, 2014, p. 27). A recommendation for educational organizations is to conduct collaborative planning processes that include all levels of the organization (i.e. horizontal and vertical). All levels of the organization that have a say in what happens or are affected by what happens, including community stakeholders, should be included in the process.

Green (2010) conducted the Campus Computing Project; a study in which 523 two-year and four-year colleges and universities participated. The survey revealed the three most important issues were (1) hiring and retaining qualified Information Technology staff, (2) financing and/or replacing aging hardware and software, and (3) instructional integration of IT.

This project revealed that one of public college and university campuses' top concerns should have been replacement of IT hardware and software. Green's (2010) study provided support that investment in IT hardware and software is critical for investing in innovative technologies.

Technology Policy

It was not until the beginning of the 21st century that documents and reports on technology outlined the necessity for new protocols and regulations to account for issues that had begun to surface with the propagation of the Internet and other virtual technologies (Culp, Honey, & Mandinach 2005). Recommendations for policy change emerged in reports including the "Web-based Education Commission's report (2000), the National Association of State Boards of Education's report on e-learning (2001), the CEO Forum report on digital content (2000), and the Future Visions report from the U.S. Department of Commerce (2002)" (Culp et al., 2005, p. 298). These reports recommend changes and updates for technological funding, content development, and professional development expansion, and could be tied to objective state goals (Culp et al. 2005). These changes could be accomplished through creating a sufficient and user-friendly technical infrastructure, updating content resources, and thoroughly training educators. Despite these recommendations, technology has been pushed to the "margins of educational practice" (Keller & Bichelmeyer, 2004, p. 21). Culp et al. (2005) also added it is often difficult to determine what constitutes quality use of technology in K-12 schools.

Culp et al. (2005) also noted it is difficult to outline a single, clearly defined set of goals for educational technology integration because of the following:

- Technologies themselves are multiple, implying different strategies of use and application;
- Technologies themselves are evolving rapidly, often far faster than schools are able to change their practices or even their purchasing plans;
- Local, state, and federal policy and budgetary environments in which schools are working are also in constant flux, making sustained investment and development difficult;
- Public perceptions of the proper role for new technologies in K-12 education continue to evolve (p. 299).

Another difficulty, which can vary widely from state to state, is policy related to technology staffing. O'Day (2002), conducted a study looking at two school divisions that had contrasting accountability approaches for implementing school reform. The study concluded that schools will implement the same plan with varied results and approaches based on personnel, expertise, and values. Coffman (2009) discussed how one state has been proactive in policy regarding technology staffing in schools. Following the No Child Left Behind Act of 2001 and the Enhancing Education through Technology program, educational leaders and lawmakers in the Commonwealth of Virginia pushed all school divisions to have their own group of specialists. These school leaders created a statewide initiative introducing a practical vision of technology integration throughout the Commonwealth of Virginia (Coffman, 2009). This specific vision fused technology within the curriculum to improve communication, the efficiency of tasks, data-driven decision-making, curriculum instruction, and student performance (Coffman, 2009).

The Virginia General Assembly approved and funded two new school-based positions in 2004: the instructional technology resource teacher (ITRT) and the technology support staff person (Coffman, 2009). The ITRT is mainly responsible for computer software and to work with teachers to implement technology in the classroom, while the technology support staff person is responsible for the hardware and repair of broken devices and systems. This legislation mandated that all 134 school divisions in Virginia hire these two-person technology teams for every school at a ratio of at least one team for every 1,000 students. As of 2009, the Commonwealth of Virginia has invested more than $500 million to support this initiative (Coffman, 2009).

The Digital Divide

Increased use of ICT in schools can have unforeseen negative consequences. One of the most frequent issues seen in the literature is the digital divide. Originally, the term digital divide defined gaps in computer access (Van Deursen & Van Dijk, 2011). However, in current educational settings, the digital divide "refers to the gap between the privileged and underprivileged members of society in terms of ability to access digital tools and the Internet" (Chen, 2015). This is most often associated with a person's ability to physically own a computer and to gain access to the Internet. Computer ownership is not 100%, but progress has been made on bridging this gap. Student computer ownership grew from 51% in 2002 to 67% in 2004 (Hawkins & Oblinge, 2006). A Pearson national student device survey in 2015 showed that 87% of students use a laptop, Chromebook, or other similar electronic device weekly in order to complete their schoolwork (Harris Poll, 2015).

However, the digital divide cannot be equated to individual ownership of a computer. Other factors also weigh heavily: “machine vintage; connectivity; online skills; autonomy and freedom of access; and computer-use support” (Hawkins & Oblinge, 2006, para. 4). Wide variations exist in the individual skills and knowledge base used to retrieve online information and in basic digital literacy skills (Hargittai 2001). Different school settings may also use similar types of technology in vastly different ways. Several studies (Warschauer, Knobel, & Stone, 2004; Wayne, Zucker, & Powell, 2002; Wenglinsky, 1998) investigated how technology was being used in correlation with the school socio-economic status (SES). These studies concluded, in low SES settings, many schools utilized computers for accomplishing lower level skills such as for drills and practice. In higher SES settings, computers were often used for activities involving writing and higher-level thinking and uses of critical analysis (Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008).

Technology Leadership

Arnold’s (2014) dissertation noted the importance of the decisions made by county supervisory leadership to the success or failure of integrating ICT resources. Teachers play a large role in determining the success, or failure, of an instructional technology initiative. County leaders, such as building-level administrators and superintendents, can have a major impact in helping teachers undertake and integrate technology comprehensively into their classrooms. “They may need to provide professional development for staff on how to use technology in the classroom” (Arnold, 2014, p. 11).

According to Arnold (2014), to adequately and successfully implement new technology initiatives, superintendents should rely on facilities, instructional, and technology leaders within the division to work collaboratively to implement a large-scale technology initiative. “If district leaders resolve technology integration problems, the potential for instructional technology to improve education may become more apparent. The relationship between instructional leadership and technology leadership is therefore important” (Arnold, 2014, p. 12).

Changing in Technology

Educational organizations often implement change through the implementation of pilot programs or by developing *islands of innovation* (Avidov-Ungar, 2010). These islands are typically seen as narrowly defined innovations that do not incorporate the organization as a whole. The implications of these narrowly defined innovations are that they do not change the organization's main values or basic assumptions (Avidov-Ungar, 2010). Narrowly defined innovations lead to partial implementation of change and often are the product of gaps between legislators and practitioners, primarily principals and teachers who hold divergent views of the execution of change (Fullan, 2006).

As noted by Argyris and Schon (1978), external values and educational values within an organization create pressure between teachers and leaders. Argyris and Schon (1978), also stated there is a gap between the visible organizational culture (the characteristics) and the underlying organizational culture (values and basic assumptions). A more pervasive concern according to Forthe (2012), is a common challenge that "is linked to demands of standard-based policy. NCLB has stunted the growth of technology use in K-12 schools. Teachers abandon innovations for explicit direct instruction which lends itself to standard-based ideology" (p. 26). When gaps exist between ideals and practice, it is difficult to develop meaningful change that also incorporates a change of values and norms, without only changing an organization's characteristics and conduct (Argyris & Schon, 1978).

There are several variables that can act as barriers to employee reception of new organizational procedures and policies. One of the barriers is failure for both individuals and organizations to recognize the necessity for change (Zimmerman, 2006). If teachers do not comprehend and value the need for change, their desire to maintain the status quo will be stronger than their disposition to accept change. Habit is another barrier to change in teacher practices (Zimmerman, 2006). Many teachers find it easier to continue instructing students in the same manner they always have, instead of developing new skills and strategies.

However, Becker (2000) suggested that as teachers increase technology use in their teaching, they begin to adopt a more constructivist approach to instruction. Past experiences, particularly those resulting in failure, can leave teachers apprehensive to make an effort to change (Zimmerman, 2006). Often, teachers develop a feeling of security from teaching practices that are familiar to them, and disrupting established patterns might trigger a fear of the unknown. In some cases, teachers can feel threatened by the prospect of change and perceive it as a threat to their expertise and abilities (Zimmerman, 2006). One way leaders can help teachers break away from sticking with longstanding habits is to utilize “a variety of strategies [that] can produce results, as long as they focus on strengthening teaching and learning, have clear objectives and establish accountability” (Childress, Elmore, & Grossman, 2006, p. 68).

Successful change within a school begins with the leader. If leaders desire for teachers to take risks, they also have to be willing to open themselves to change and be willing to reveal their own limitations through learning themselves (Zimmerman, 2006). Leaders who display confidence and resolve can inspire their teachers to become risk takers themselves. “The additional challenges that technology integration present only amplify the need for strong leadership. K-12 leaders need to send clear and coherent messages to teachers if they are to have any level of success in establishing real change” (Forthe, 2012, p. 35). Leaders must be capable of aligning their schools’ vision, goals, organizational systems, instructional strategies, and culture in order to ascertain areas for improvement (Zimmerman, 2006). Leaders must also be able to earn their teachers’ trust. Leaders who oversee successful organizations hold themselves responsible when problems occur but are also quick to deliver positive feedback and support with colleagues when the organization experiences success (Zimmerman, 2006).

School Facilities and Infrastructure

“Fundamentally, an organization is the connection and coordination of components into a structure for performing vital functions and processes” (Leutscher, 2005, p. 6). The school facility connects and coordinates capital, human, mechanical, and technical components to achieve the desired outcome of promoting academic learning of children (Leutscher, 2005). Meeks (2014) stated a school’s infrastructure is primarily made up of HVAC systems, AC power, and cable pathways. According to Durán-Narucki (2008), “The school is the most important setting, after the home, in the development of children” (p.279). In order to make effective academic use of a facility, several features are taken into consideration, including age of the building, temperature control, air quality, lighting, and acoustics (Cash, 1993; Earthman, 2009; Lanham, 1999; Maxwell & Evans, 2000; Wurtman, 1975).

Chan (1996) discussed how new school buildings can accommodate the needs of current academic programs because they house the most recent and innovative technological needs.

However, older school facilities that are considered obsolete cannot meet existing demands because of changes in mechanical and technological needs. School infrastructure inadequacies can be traced back to the 1950s when there was a need to build new schools quickly and cheaply due to rising student enrollment from post-WWII baby boomers (Tanner & Lackney, 2006). Due to consistently rising costs for materials and labor, many divisions delay building projects or delay the scope of work to be completed, further exacerbating the issues of the facility (Chan, 1996).

Alexander and Lewis (2014) outlined a 1999 National Center for Education Statistics report by noting,

> based on survey responses, 53 percent of public schools needed to spend money on repairs, renovations, and modernizations to put the school's onsite buildings in good overall condition (see table 5). The total amount needed was estimated to be approximately $197 billion, and the average dollar amount for schools needing to spend money was about $4.5 million per school (p. 3).

The report also showed an average of 44 years since school divisions had completed construction of the primary section of an instructional building. School divisions showed an average of 12 years since a major renovation of the primary instructional building. Additionally, in respect to schools with major building replacement or addition, those changes occurred an average of 16 years ago. A report from the National Center for Education Statistics (2000) stated,

> three-quarters of schools reported having facilities that were in fair or poor condition. Eleven million students were enrolled in schools reporting inadequate environmental conditions. These maintenance conditions varied by concentration of poverty: schools with the highest concentration of poverty were more likely to report poor conditions" (para. 2).

In a report by Dickerson and Ackerman (2016), approximately one-third of schools nationwide have inadequate conditions, impacting fourteen million students.

According to a Report Card for America's Infrastructure by the American Society of Civil Engineers (2013),

> Public school enrollment is projected to gradually increase through 2019, yet state and local school construction funding continues to decline. National spending on school construction has diminished to approximately $10 billion in 2012, about half the level

spent prior to the recession, while the condition of school facilities continues to be a significant concern for communities. Experts now estimate the investment needed to modernize and maintain our nation's school facilities is at least $270 billion or more (p. 7-8).

Earthman (2009) supported this finding in his text on *Planning Educational Facilities*. In one case example, he stated a particular school building was designed during a time when technology was not of great importance. The building lacked sufficient electrical power and the necessary electrical outlets to allow for an increase in technological equipment. There was also a lack of audio/visual communications between classrooms and other rooms throughout the building. The older cooling system was not able to keep up with the increased demands of newer computer laboratories.

School Facilities Power Needs

According to Thornburg (2009), "The constantly changing landscape of educational technology can be thought of as a series of transitions from older tools to newer ones" (p. 1). According to Meeks (2014), when schools first started being wired with networks for computer use in the classroom, the computers were such power hogs that putting two in one classroom would trip the circuit breaker. In recent years, a basic consideration for all schools is to design methods for handling the power load associated with the numerous devices staff and students will be using (Thornburg, 2009).

A desktop computer uses approximately one hundred fifty watts of power, while a laptop uses about thirty watts per hour (Thornburg, 2009). Recent advances, such as Chromebooks, use less than ten watts per hour and will help schools manage an impending power crisis. Meeks (2014) stated, "when we talk about today's student and teacher devices, the AC power need is more related to how we enable recharging the device's battery in the classroom" (p. 115). Laptops and other low-power devices usually have battery life lasting more than six hours, allowing for charging in the evening when power load on the rest of the system is minimized (Thornburg, 2009). According to Meeks (2014), another consideration for AC power outlets in classes are rooms intended to use for online assessments. Not only are extra outlets needed, but also their location should align with the desks or tables needing to be arranged for testing.

Infrastructure Cost and Needs

Another major expense in school technology is the cost of the infrastructure that enables Internet access and web-based tools for instructional programs and learning (Schwab & Foa, 2001). Infrastructure enables devices to be networked, allowing users access to monitoring and communication tools. The overall perceived success or failure of a technology initiative by a school's stakeholders could heavily depend upon the quality of the infrastructure (Schwab & Foa, 2001). "Infrastructure should be invisible; we should not have to think about it. Electricity, water, sewage, transportation, and communication are part of the infrastructure of a modern society, yet the average citizens spends no time thinking about these services unless, of course, something goes wrong" (Leutscher, 2005, p. 19).

According to Schwab and Foa (2001), school divisions can purchase high-quality laptops with excellent software programs and online tools, but if the infrastructure is not in place to support multiple users accessing those programs and tools concurrently, then the users can become frustrated and resistant to future attempts to move forward with the initiative. The infrastructure must be in place before the devices are in the users hands and must be able to handle the capacity of data based upon the size of the district (Schwab & Foa, 2001).

Information Technology (IT) Infrastructure

In order for students to have access to the Internet, major upgrades to the school infrastructure must be in place (Harris, 2014). Equipment such as wireless hubs and specialized fiber optic cable are needed to utilize technologies such as laptops and electronic whiteboards, and to promote twenty-first century learning (Harris, 2014). The Universal Service Administration Company (USAC) Schools and Libraries (2009) indicated that technology resource management is a continuous challenge for any organization heavily invested in IT resources. USAC Schools and Libraries (2009) also indicated the data center model is an ideal model for school divisions. A data center is a space used to protect computer systems and integrated device components such as, server storage systems and telecommunication systems. Managed Service is defined as remotely facilitating external IT resources (USAC Schools and Libraries, 2009) and is another viable choice for schools because it allows them to benefit from using a data center without the responsibility of investing organizational capital.

Once IT infrastructure has been put into place, it must also be regularly serviced and upgraded to retain adequate performance according to Dell Incorporated (2006), which stated IT infrastructure that comprised aging and varied technology platforms inhibited technology‘s effect on student achievement and long-term success of technology platforms and programs. According to 3Com Corporation (2010), many school divisions across the United States suffer from a lack of uniformity with hubs, switches, and devices resulting in a network with performance issues that are difficult to troubleshoot. It is not an advised practice for organizations to use equipment nearing the end of its life cycle. Allowing this can result in a technology program incurring increased cost, decreased efficiency, and can impede overall platform performance and dependability (Dell Incorporated, 2006). Dell Incorporated (2006), suggested that a possible solution is replacing the Local Area Network (LAN) with standardized equipment and the use of best practices with fidelity, resulting in improved IT network performance. Better efficiency results in lower costs and a savings in time. Standardized equipment also provided dependability and sustainability to the IT infrastructure (Dell Incorporated, 2006).

Infrastructure Supports for the Internet

School systems attempting to keep pace with advancements in technology used over the course of multiple decades will have to develop systems to account for speed, access, and storage (Thornburg 2009). As more devices are added into a wired and/or wireless network, speed and performance can be reduced by bandwidth. Bandwidth is measured in bits or megabits per second, and describes the size of the path along which data are transferred (Koski, 2011). Installing fiber optic cable noticeably increases bandwidth and is a viable solution for new school construction and improvements (Koski, 2011).

A study developed by Arnold (2014) interviewed five superintendents whose divisions had implemented a one-to-one device initiative and found that “robust and reliable Wi-Fi networks were recognized as being critical to gaining acceptance by teachers for 1:1 initiatives. A reliable network is one that is rarely, if ever, not functioning properly (operational 99.9% of the time)” (p. xxiii). A major recommendation from this study was for district leaders to make the necessary investments in their wireless networks to ensure they are robust and reliable.

According to CableFax Staff (2014), FCC chairman Tom Wheeler plans to modernize the E-rate program, which provides discounts to help schools and libraries receive communications services. Wheeler proposed increasing federal funding for Wi-Fi by 75% in rural schools and 60% in urban schools and libraries. That equates to an additional 44 million students and 16 thousand libraries gaining access to Wi-Fi services by 2019, all within existing program funding (CableFax Staff, 2014). Wheeler proposed two changes, including phasing down $1.2 billion support for non-broadband services and repurposing it for Wi-Fi, making prices more transparent and facilitating greater use of consortia-enabled bulk purchasing (CableFax Staff, 2014). Comcast, a backer of Wheeler's E-rate overhaul in general, wanted the fund to support items including caching services, bandwidth optimizers, Wi-Fi equipment, and services that provide similar functionalities, according to a recent FCC filing (CableFax Staff, 2014).

CableFax Staff (2014) also reported that Bright House, a telecommunications company, while supportive of the Wi-Fi funding, worried that if a large proportion of high-discount schools chose to take all their funding up front, they could potentially claim the entire $1 billion provided for the first year, and most likely, the entire $1 billion provided in the second year. The company advocated encouraging schools to purchase Wi-Fi as a service by allocating some funding to all schools every year for Wi-Fi. "When purchased as a service, there is no upfront capital investment required of the school and therefore, no need to front-load the funding in the 1st year that a school obtains Wi-Fi" (CableFax Staff, 2014, lines 24-26). Bright House also suggested the FCC let schools conduct a bidding process after they know they will receive E-rate funding.

Rural School Technology Infrastructure

Yax (2002) defined a rural school division as any whose district office is not located in a city center or metropolitan area based on data from the National Center for Education Statistics. According to Vidoni (2004), “in the wake of the 1990’s thrust to bring information technology to rural districts, such districts are faced with the challenge of maintaining, upgrading, facilitating, and integrating these technologies” (p. 20). Acquiring information technology (IT) equipment is often more challenging for rural schools than it is for their urban counterparts (Katsinas & Moeck, 2002; Silvis, 2000; Staihr & Sheaff, 2001; Vidoni, 2002). Acquiring equipment is not the only issue. Hawkes, Halverson, and Brockmueller (2002) explained that for many rural school divisions, maintaining and facilitating this equipment is just as difficult as acquiring it. IT equipment requires a local pool of technology professionals who are capable of fulfilling school division needs for information technology integration (Hawkes et al, 2002). IT equipment requires a large budget and administrative support. The difficulty for many rural school divisions is the ability to successfully and efficiently carry out some or all of these components (Hawkes et al., 2002).

Carter (1997) agreed that maintaining and facilitating technology use in school involves many tasks and operations. The most important of these tasks include network system management and the installation and maintenance of hardware and software. Maintenance at this level also requires servicing numerous email and user accounts for staff and students as well as responding to other network issues (Carter, 1997). “Weekly system backup has to be done as well as repairs and upgrades on serviceable items” (Hawkes et al., 2002, p. 162). Newer tasks in the coordination of technology use in the schools also include satellite downlinking, interactive video system bridging, and video production, editing, and distribution (Carter, 1997).

Multi-person technology support teams are increasingly common in larger school divisions (Reilly, 1999). A common model involves a three-member team approach; a technology coordinator to lead the effort, oversee the budget, order equipment, keep up to date with technology changes, and communicate with administrators; a technical person to install the equipment, IT trouble-shoot, and answer application questions; and a technology curriculum specialist to help the staff apply the technology in meaningful and engaging ways (Reilly, 1999). Multi-person technology support teams have been instrumental in ensuring efficient and effective technology use in schools. Unfortunately, sustaining these teams is costly and often beyond the financial reach of rural schools and divisions (Reilly, 1999).

Summary

This literature review focused on topics relevant to the facility and infrastructure needs to support technology initiatives in schools. The literature supported that multiple levels of infrastructure and technical supports must be in place for technology initiatives to maintain short and long-term success (Harris, 2014; Leutscher, 2005; Schwab & Foa, 2001). Schools and divisions that do not have an effective organizational technology infrastructure to support their information and communication technology initiatives can often experience inefficient and ineffective technology usage within their buildings.

Appropriate and comprehensive technology policies for sustainable technology use within schools can be accomplished through creating an adequate and accessible technical infrastructure, updating content resources, and thoroughly training educators (Arnold, 2014; Culp et al. 2005). Mandating statewide policy changes can ease or increase the burden on local school divisions to create these types of technology initiatives. For example, the Commonwealth of Virginia pushed every school division to have its own team of technology-integration specialists to help support the addition of technology in schools, such as the one-to-one device initiative (Coffman, 2009).

Over the past two decades, school systems have had to work to overcome the initial digital divide of device inequity. Now, the digital divide is not focused on lack of devices, but on access to the Internet and other web-based programs, particularly in homes throughout the school community (Chen, 2015). Some school divisions have tried to combat this problem by launching pilot programs to issue wireless Wi-Fi hotspots to students to take home for use with their school-issued laptops. This benefits many additional stakeholders in the community beyond students who may otherwise not readily have access to Internet capabilities at home (Cavanagh, 2014).

Research indicates that teachers play a large role in determining the success or failure of an instructional technology initiative (Arnold, 2014). County leaders, such as building-level administrators and superintendents, can have a major impact in helping teachers accept and fully integrate technology into their classrooms. To adequately and successfully implement new technology initiatives, superintendents should rely on facilities, instructional, and technology leaders within the division to work collaboratively to implement a large-scale technology initiative (Arnold, 2014).

Research in the area of school facilities and infrastructure needs has discovered information to help educational leaders make decisions about these programs in their divisions. However, several studies indicated that specific research in the area of technology infrastructure is limited. Carmo (2013) found that “the scholarly literature documenting studies of university technology assessment is very sparse. Further, the studies that are available are limited in the information and data they provide” (p. 16). Arnold (2014) stated

> There does not appear to be a comprehensive, individualized, research based guide to technology integrations that takes into account the unique political, cultural and socioeconomic characteristics of various school districts that are considering this movement. There is also no research-based study available to superintendents to help

them understand and consider the leadership moves that may help them gain acceptance for a large-scale technology movement (p. v-vi).

According to Vidoni (2004), “research that specifically studies the state and application of information technology in the rural U.S. is sparse. In fact, research on U.S. rural education in general is not extensive” (p. 17). Given the limited research specific to school technology infrastructure, this study is needed to further expand upon the information available to school and technology leaders in determining what decisions and resources are necessary to have the appropriate technology infrastructure in place to successfully support a technology initiative in their district.

CHAPTER THREE
METHODOLOGY

Introduction

The purpose of this study was to determine the planning and implementation practices necessary for facilities infrastructure to support technology initiatives in two rural school divisions in Virginia. The following were the driving research questions for this study: (1) What short-term and/or long-term plans are in place for building and maintaining facilities infrastructure to support technology initiatives? (2) What physical components, equipment, and personnel are necessary for adequate facilities infrastructure to support technology initiatives? (3) What are the perceived infrastructure barriers to effective integration of technology in a school building? This chapter describes the design of the study, the selection of participants, the data collection procedures, and a description of the qualitative analysis that was used to evaluate the data.

Design of the Study

A qualitative methodology was selected for this study as it provides an understanding of the infrastructure needs to support technology initiatives in a rural school setting. Qualitative research uses an approach that attempts to understand phenomena in context specific settings (Hoepfl, 1997). This study utilized the qualitative research method of a case study, which is an in-depth description and analysis of a confined system (Merriam & Tisdale, 2015). According to Mitchell (2011), "the focus of the case study may be a single individual, as in the life-history approach, or it may be a set of actors engaged in a sequence of activities either over a restricted or an extended period of time" (p. 3). Yin (2009), stated "case studies are the preferred method when (a) 'how' or 'why' questions are being posed, (b) the investigator has little control over events, and (c) the focus is on a contemporary phenomenon within a real-life context" (p. 2).

Within the case study design, the researcher can develop a single-case or multiple-case study design. According to Yin (2009), "a common example [of a multiple-case design] is a study of school innovations (such as the use of new curricula, rearranging school schedules, or a new educational technology), in which individual schools adopt some innovation" (p. 53).

Regardless of the type of case study chosen, the researcher must follow similar procedures for data collection. This may include defining the case, developing research questions, identifying data sources, and determining a protocol for reporting (Stake, 1995). The subsequent results can then be used to generate both hypotheses and proposals for future studies (Yin, 2009). The case study design is the most appropriate for this study as it allows for the specific phenomena to be analyzed in depth and from varying points of view. This method allows for triangulation of data points to bolster the validity of the findings.

Population

This study was conducted in two rural school divisions in Virginia. The first school division was made up of two elementary schools, a middle school, a high school, and a regional technical center serving approximately 3,100 students. All 100% of its schools were fully accredited for the 2016-17 school year. As of the 2014-15 school year, this division contributed 47% toward the cost of per-pupil spending (VDOE, 2017). This division has seen a recent overhaul of their technology infrastructure in order to make technology amply available to teachers and students in grades 6-12 with a one-to-one Chromebook device initiative.

The second division was made up of one K-2 primary school, one 3-5 elementary school, a middle school, and a high school serving approximately 2,200 students. All 100% of its schools were fully accredited for the 2016-17 school year. As of the 2014-15 school year, this division contributed 39% toward the cost of per-pupil spending (VDOE, 2017). It was currently undergoing an overhaul of its technology infrastructure to be able to support a one-to-one Chromebook initiative to begin in grades 9-12, eventually expanding to grades 6-8, and then into the upper elementary grades. This initiative has been delayed twice due to lack of funding and technology infrastructure.

Sample

In qualitative studies, purposeful sampling is one of the prevailing sampling strategies. Purposeful sampling pursues cases that can be studied in depth (Patton, 1990). Gobo (2011) stated that purposeful sampling “consists of detecting cases within extreme situations as for certain characteristics or cases within a wide range of situations in order to maximize variation” (p. 11). The interview participants selected for this study were division-level directors of technology and their technology staff, ITRTs and technology support staff. The participants taking part in this purposeful sampling were at various stages of their profession, and at differing years of service, within their respective school divisions. Directors of technology in both participating divisions were interviewed individually. The technology personnel in both divisions were interviewed in a focus group setting. Each participant was notified of his or her right to withdraw from the study at any time. All participants were assured confidentiality as an individual participant and as a part of the individual school they worked for in order to avoid identification.

Instrumentation

Qualitative case studies can utilize various means for collecting information. Baxter and Jack (2008), stated “potential data sources may include, but are not limited to: documentation, archival records, interviews, physical artifacts, direct observations, and participant-observation” (p. 554). Another method for collecting information in a case study is the focus group. Sim (1998) stated, “the focus group has gained considerable popularity as a means of gathering qualitative data” (para. 1). Kitzinger (1995) added that focus groups “can encourage participation from people reluctant to be interviewed on their own or who feel they have nothing to say” (p. 299). The source of data collection for this study consisted of separate recorded interviews with the division-level technology leaders and focus group interviews with technology staff personnel in each of the two school divisions.

This study utilized open-ended interview questions that allowed for individual variations. The purpose of the interviews and focus groups was to learn about what priorities the technology leaders and their staff place on certain aspects of their division’s technology infrastructure. The interviews and focus groups also sought to determine what infrastructure barriers the technology leaders and their staff believed might impact the consistency of technology integrated in their buildings. Additionally, the interviews and focus groups attempted to seek the reflections of technology leaders and their personnel on how they believe aging school facilities impact their capacity for infrastructure to support technology initiatives.

This study also incorporated the review of various division-wide documents germane to the building and maintenance of facilities infrastructure. Coupled with the individual and focus group interviews, the review of these documents formalized a triangulation of the qualitative research components of this study. “Triangulation refers to the use of multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena” (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014, para. 1). Major documents to be reviewed included division-wide long-range plans, technology plans, capital improvement plans, and school board meeting minutes/notes.

An interview protocol was developed to direct the conversations with the interview and focus group participants (see Tables 1-8 below). The questions developed for this interview protocol were based on common themes and ideas present during the researcher’s review of literature. A group of technology personnel and administrators who were currently employed by a public school division reviewed the questions to provide feedback and ascertain if the questions were valid and aligned to the research questions. The interview protocol was then revised based on the expert panel’s feedback and suggestions.

Table 1

Interview Questions Factor 1: Information

Questions:
1. What is your current job title and basic job description?
2. How long have you been apart of this school division?
3. What other positions have you held prior to your current position that prepared you for this job?

Table 2

Interview Questions Factor 2: Planning

Questions:
1. How does your school division plan for the development/improvement of facilities infrastructure to support technology initiatives?
2. How often does your school division revise/update this plan?
3. How do you prioritize the components necessary to maintain this plan?
4. What major technology initiative(s), if any, does your current plan attempt to develop and/or maintain?

Table 3

Interview Questions Factor 3: Structure/Equipment

Questions:
1. How old is each of the school buildings in your division?
2. What are the major structural components and/or equipment necessary for your division to implement its currently planned technology initiative(s)?
3. Does your school division currently have all the structural components and/or equipment in place that is necessary to implement its currently planned technology initiative(s)?
4. If yes to question 3, what factors allowed you to meet your needs? If no to question 3, what is still necessary to meet your needs?
5. What are the perceived infrastructure barriers, if any, that cause school and technology leaders not to integrate technology consistently into their building?
6. Does the age of your school division's buildings support or impede its ability to develop and/or maintain its infrastructure? Please explain specific examples.

Table 4

Interview Questions Factor 4: Personnel/Professional Development

Questions:
1. How many other staff members work under you to maintain your technology infrastructure plan?
2. Do you have all the staffing necessary to carry out your technology infrastructure plan? If not, what other personnel do you still need and why?
3. How often and what types of technology infrastructure needs are contracted to companies outside of your division? Why are these issues not able to be completed by school division employees?
4. What opportunities does your school division provide for training your technology staff on maintaining and upgrading technology infrastructure?

Table 5

Interview Questions Factor 5: Other Factors/Information Not Specified

Questions:
1. What other factors or information not already discussed in this (interview/focus group) would be important to know about regarding how your school division builds/maintains its school facilities infrastructure to support technology initiatives?
2. Are there any barriers to your division's school facilities infrastructure not already discussed in this (interview/focus group)? If so, please define the barrier(s) and its impact on carrying out technology initiatives in your school division.
3. What documents can you provide that will provide further evidence of your district's efforts to develop facilities infrastructure to support technology?

Table 6

Interview Questions Categorized by Research Question

Research Question 1	**What short-term and/or long-term plans are put in place for building and maintaining facilities infrastructure to support technology initiatives?**	**Interview Table & Question**
Interview Questions	How does your school division plan for the development/improvement of facilities infrastructure to support technology initiatives?	T2Q1
	How often does your school division revise/update this plan?	T2Q2
	How do you prioritize the components necessary to maintain this plan?	T2Q3
	What major technology initiative(s), if any, does your current plan attempt to develop and/or maintain?	T2Q4
	How many other staff members work under you to maintain your technology infrastructure plan?	T4Q1
	Do you have all the staffing necessary to carry out your technology infrastructure plan? If not, what other personnel do you still need and why? What documents can you provide that will provide further evidence of your district's efforts to develop facilities infrastructure to support technology?	T4Q2
	What documents can you provide that will provide further evidence of your district's efforts to develop facilities infrastructure to support technology?	T5Q3

Table 7

Interview Questions Categorized by Research Question 2

Research Question 2	**What physical components, equipment, and personnel are necessary for adequate facilities infrastructure to support technology initiatives?**	**Interview Table & Question**
Interview Questions	What are the major structural components and/or equipment necessary for your division to implement its currently planned technology initiative(s)?	T3Q2
	Does your school division currently have all the structural components and/or equipment in place that is necessary to implement its currently planned technology initiative(s)?	T3Q3
	If yes to the question above, what factors allowed you to meet your needs? If no, what is still necessary to meet your needs?	T3Q4
	How often and what types of technology infrastructure needs are contracted to companies outside of your division? Why are these issues not able to be completed by school division employees?	T4Q3
	What opportunities does your school division provide for training your technology staff on maintaining and upgrading technology infrastructure?	T4Q4
	What other factors or information not already discussed in this (interview/focus group) would be important to know about regarding how your school division builds/maintains its school facilities infrastructure to support technology initiatives?	T5Q1

Table 8

Interview Questions Categorized by Research Question 3

Research Question 3	**What are the perceived infrastructure barriers to effective integration of technology in a school building?**	**Interview Table & Question**
Interview Questions	How old is each of the school buildings in your division?	T3Q1
	What are the perceived infrastructure barriers, if any, that cause school and technology leaders not to integrate technology consistently into their building?	T3Q5
	Does the age of your school division's buildings support or impede its ability to develop and/or maintain its infrastructure? Please explain specific examples.	T3Q6
	Are there any barriers to your division's school facilities infrastructure not already discussed in this (interview/focus group)? If so, please define the barrier(s) and its impact on carrying out technology initiatives in your school division.	T5Q2

The interview protocol was then tested through a practice interview. The practice interview was used to further ensure the interview protocol produced valid information relevant to the research questions. Participants of the practice interview were asked to provide feedback regarding the validity and alignment of the interview questions to the research questions. Adjustments were made to the interview protocol based on the feedback of the practice interview participants (Hays & Singh, 2011).

The researcher was trained regarding the IRB process (see Appendix A). Before interviews were conducted, the researcher gained approval from the Virginia Polytechnic and State University's Institutional Review Board (see Appendix B). The researcher then gained approval from the superintendent, or their designee, of both school divisions selected to participate in the study (see Appendices C-D). Once superintendents, or their designee, gave consent for individual interviews and focus group interviews to be conducted in their school division, a letter was sent to each of the possible respondents (see Appendix E). The letter, attached in an email (see Appendices F-G), informed possible respondents of the purpose of the study and gave them the opportunity to accept or decline involvement in the study.

After participants verbally confirmed their intent to participate in the study, the researcher worked with the participants through email to develop a mutually agreed upon time and place for the interviews to take place (see Appendix H). Prior to each interview beginning, participants were asked to sign an informed consent form that follows the requirements of the Virginia Polytechnic and State University's Institutional Review Board (see Appendices I-J). The researcher then interviewed and digitally recorded the participants from the selected rural school divisions. After the interviews and focus groups were completed, the interviews were transcribed.

In order to protect the confidentiality of each individual participant, each participant in the interview or focus group was assigned a coded letter and number combination (see Table 9). This ensured the confidentiality of the school divisions participating in this study. The researcher was the only person who had access to any identifiable information belonging to the individual participants and school divisions. Individual interview participants were notified of 1) their right to confidentiality during the interview process, and 2) steps that were taken to ensure their confidentiality.

Table 9

Interview and Focus Group Coding

Title	Code	Example	Code
School Division #1	A	Technology Director of School Division #2	BT1
School Division #2	B	Technology Personnel of School Division #1	AP2
Technology Director	T		
Technology Personnel	P		

Data Analysis

Flick (2014) described data analysis as "the classification and interpretation of linguistic (or visual) material to make statements about implicit and explicit dimensions and structures of meaning-making in the material and what is represented in it" (p. 5). Once individual and focus group interviews were completed, the digitally recorded interviews were transcribed. The interview data were then analyzed by identifying themes, or codes, and linked to categories of similar codes (see Table 10). According to Merriam and Tisedell (2015), "categories are conceptual elements that 'cover' or span many individual examples (or bits or units of the data you previously identified) of the category" (p. 206). As additional interviews and focus groups were transcribed and coded, the data were analyzed, new codes identified, and changes were made.

Confidentiality

All identifying names and personal information were removed from the collected data. A coded letter and number combination was used in place of the names of the participating respondents and the school systems involved in the case study (see Table 9 above). Recordings and transcriptions of the interviews were accessed only by the researcher and were kept in a electronically locked safe. Audio data from the transcriptions of the digital recordings were destroyed after the successful defense of the dissertation. Paper copies of the transcription of the interviews will be kept for one year following the defense of the dissertation.

Table 10

Possible Data Analysis Codes

Code Type	Sub Code Type	Code
Vision/Goals	Long-range plan	LRP
	Technology plan	TP
	Capital Improvement plan	CIP
Building Condition	New Building	NB
	Recently Renovated	RR
	Needs Renovation	NR
	Demolition/Abandonment	DA
Equipment/Materials	Access Points	AP
	Fiber	F
	Servers	S
	Switches	SW
	Bandwidth	BW
Personnel	Director of Technology	DT
	ITRT	IT
	System Operator	SO
Professional Development	Systems (software) Training	SST
Identified Barriers	Funding	F
	Out of Date Equipment	ODE
	Insufficient Planning	IP
	Lack of Personnel	LP
	Cabling	C

Timeline

The interview and focus question protocol for this study was developed in June 2017. The interview protocol was established and tested through a practice interview during Summer 2017. Upon completion of the practice interview, revisions were made based on the feedback provided. The interview protocol was submitted to the researcher’s dissertation chair for review. The researcher submitted the proposed study to Virginia Tech’s Institutional Review Board in Fall 2017. After gaining IRB approval, interviews and focus groups were scheduled for participants during Fall 2017. The interview and focus group responses were transcribed and analyzed to determine themes to be coded during late Fall 2017.

Summary

The purpose of this study was to determine the planning and implementation practices necessary for facilities infrastructure to support technology initiatives in two rural school divisions in Virginia. The participants were purposefully interviewed from two Virginia school divisions; one that recently had developed the infrastructure necessary to support a one-to-one student laptop initiative, and another that is currently working toward that goal. The qualitative methodology utilized in this study included a multiple-case study design. Through the completion of a practice interview, the interview protocol was revised. Recorded interviews and focus groups were conducted at a location and time convenient to the participants. Key categories from the interview transcripts will be discussed in the following chapter. The findings of this study may help division superintendents and division technology leaders make more informed decisions regarding school facilities infrastructure to support technology initiatives.

CHAPTER FOUR
RESULTS

Introduction

This chapter presents the results of data collected in this study. The means of data collection for this study were through individual and focus group interviews of participants, as well as a review of division documents pertaining to school technology infrastructure. Data were analyzed in this study through the use of a qualitative methodology and multiple-case study design. The purpose of this study was to seek reflections of school leaders and their staff on facilities infrastructure needs to support technology initiatives in two rural school divisions in Virginia. The demographics of the school divisions participating in this study is outlined.

Population

The target population for this study was technology leaders and technology personnel in two rural public school divisions located in Virginia (see Table 11). Division A has a technology staff of five members and a director of technology position that serve a total student enrollment of approximately 3,100 students. The technology staff includes three ITRTs, an IT help desk position, and a network administrator. Division A has seen a recent overhaul of their technology infrastructure in order to make technology amply available to teachers and students in grades 6-12 with a one-to-one Chromebook device initiative. Division B has a technology staff of four members and a director of technology position that serve a total student enrollment of approximately 2,200 students. The technology staff includes two ITRTs and two technology specialists that oversee the hardware and maintenance of the technology infrastructure within the school division. Division B is currently undergoing an overhaul of its technology infrastructure to be able to support a one-to-one Chromebook initiative to begin in grades 9-12, eventually expanding to grades 6-8, and then into the upper elementary grades.

Table 11

Participant Demographics

Current Job Title	Years of Exp.	Previous Job Title	Previous Job Years of Exp.	Code
Network Administrator	13	None	None	AP1
ITRT	1	ITRT	11	AP2
ITRT	5	Teacher/Tech Support	10	AP3
ITRT	2	ITRT	8	AP4
Director of Technology	14	Computer Tech	2	AT1
Technology Specialist	3	Technology Specialist	6	BP1
ITRT	8	Teacher	21	BP2
Technology Specialist	3	Server Administrator	16	BP3
Director of Technology	1	ITRT	12	BT1

Data Collection

IRB training and study approval through Virginia Polytechnic and State Institute was obtained prior to any contact with study participants. After gaining IRB approval, member checks from educational professionals were obtained to gain feedback about the interview questions, and to ensure the interview questions aligned with the study's research questions.

Permission was then obtained from both division Superintendents (or their designees) to interview technology leaders and staff within their divisions. Once division permission was obtained, a letter was sent to possible participants attached in an email. Members responded via email to indicate whether they wished to participate in the study or not. Those who indicated they would participate in the study were sent follow up emails to determine a time and place for the interview to take place.

Before the interviews began, the researcher distributed and reviewed the informed consent form for all participants to read and sign. Once informed consent was obtained from all participants, the individual and focus group interviews were conducted. Each interview was digitally recorded. After all interviews were completed, each interview was transcribed. The transcriptions were then coded to find common themes. The researcher also reviewed supporting division documents that outlined the planning and implementation of technology initiatives in both school divisions. Interview data presented in this chapter were organized by each of the three research questions.

Research question 1. What short-term and/or long-term plans are put in place for building and maintaining facilities infrastructure to support technology initiatives?

Table 12 outlines interview participant responses regarding long-term technology plans. Respondents discussed in all four interviews the necessity for a state mandated technology plan that is updated every five years. Respondents also stated the five-year state mandated plan was not sufficient or representative of the division's current technology needs. Respondents felt the five-year state plan did not afford the ability to remain flexible and constantly make changes to the technology needs of the division. Respondent BT1 confirmed this by stating the five-year state mandated technology plan "is not really realistic to keep up with technology needs" (transcription line 51).

Table 12

Usage of Long-term Plans

Quote	Code	Transcription Line
We do have somewhat, well based on state requirements, we have school and division technology plans that are written down… official written technology plans so it was supposed to be once every three years, the state pushed it to once every five.	AP3	60-65
So nothing formally set, we do the state plan, it's a lot of paper and I guess targets aren't what they were five years ago, they're completely different.	AT1	55-57
I think we have a five-year technology plan currently right? It is changing some this year. And often times even with our five-year plan, things arise that are unexpected and may change our plan or add to it.	BP3	64-65, 74-75
Of course we have our six-year plan that aligns with the state. As far as revising and updating this plan, so the state requirement of the six-year technology plan is not really realistic to keep up with technology needs.	BT1	27, 49-51

Table 13 outlines respondents' perceptions of more flexible, short-term technology plans. Aside from the five-year state mandated technology plan all divisions are required to complete, each division maintains a less formalized technology plan that evolves constantly to keep up with the changing needs of the division's technology initiatives. These plans are frequently reviewed and updated based on formal and informal meetings of technology personnel. Technology personnel also work with other division staff (ex: teacher stakeholder groups, superintendent, etc.) to determine any changing needs for the technology plan. The difference between long-term and short-term planning was the long-term five-year state technology plan was essentially a document for public consumption, while a short-term, internal technology plan was constantly revised and updated to meet the changing technology needs of each division.

Table 14 captured responses regarding major technology initiatives currently being undertaken in their respective school divisions. Based on multiple responses in each interview from both divisions, one-to-one Chromebook initiatives were the major technology initiative discussed. Both divisions reported beginning their Chromebook initiatives at the high school level and outlined plans to expand the initiative to lower grades within the middle and elementary school levels over time.

Table 13

Usage of Short-term Plans

Quote	Code	Transcription Line
We do have a technology plan, but that’s something that evolves every day. It’s not something that we say every three years we are going to change, or anything like that, I mean, it’s every day.	AP1	48-51
That plan generally does change with the times.	BP1	70
And often times even with our five-year plan, things arise that are unexpected and may change our plan or add to it. That wasn't obviously in our five-year plan but there are things like that that come up that we did have to revise it when needed.	BP3	74-78
As far as revising and updating this plan, the state requirement of the six-year technology plan is not realistic to keep up with technology needs.	BT1	49-51
And we work slowly as we have meetings, our own technology meetings, and we discuss it on our own.	BP1	69-70
We also have monthly meetings, once a month or once every other month. The technology advisory meetings. Someone from the school district... meet with us, and request stuff and their issues and problems with the current technology at the schools.	BP1	55-58
Basically once a week I just re-review some of my lists. Look to see what sort of projects are out of horizon.	AT1	34-35
There are two technology plans that most divisions have. They have their six-year plan that they have to submit to the state. And that is roughly followed at best. And then you have the realistic technology plan that's updated every six months to a year, as things change. It needs to be more fluid. The state plan is the public-facing document, and then the internal technology plan as things change, is a little more what is followed.	BT1	88-93

Table 14

Major Technology Initiatives

Quote	Code	Transcription Line
So we have the one-to-one at the high school currently. We would like to bring the middle school on as soon as possible.	BT1	112-113
Well, we have the one-to-one currently at the high school. With hopes of expanding the one-to-one to the middle school, as well.	BP2	97-98
We are on the last year of our one-to-one at the middle school, high school. So it's how to keep it going, how to keep it within the same parameters that the instructional folks deem successful.	AT1	89-91
The one-to-one I think is the biggest I would say.	AP2	104-105

Table 15 provides responses regarding how technology plan components were prioritized within both school divisions. This table defines two distinct themes, one from both directors of technology, and one from both divisions' technology personnel. The theme from the two directors of technology generated responses outlining where the focus for technology initiatives within the division were derived. Both respondents indicated that central office administration and the school board were most influential in determining the division-level focus for both directors of technology. Instead of discussing the source of division-wide technology priorities, the theme from the two technology personnel interviews included a variety of structural components necessary to maintain optimization of technology infrastructure within the division. Among these were switches, servers and bandwidth.

Table 15

Prioritization of Technology Plan Components

Quote	Code	Transcription Line
Getting our one-to-one off the ground was the school board's directive last year.	BT1	69
It's a lot based on where the [central office] administration wants to go.	AT1	63
LMS and, you know, maintain the infrastructure and keeping up with bandwidth and that kind of stuff.	AP3	107-108
I've got migrate to Windows 10, more cloud storage, more virtual machines, VMs, more redundancy, better switches.	AP1	115-116
With basis of how much it affects someone, like if our server goes down then that's top priority. If our core [switch or router] goes down that is top priority. Just because, if those goes down it affects a lot of people. Then from there it goes slowly down to probably a student machine, to a teacher machine.	BP1	87-90

Table 16 outlines the number of technology personnel employed in a rural public school division. The table illustrates a similar structure between the technology personnel of Division A and Division B. Both divisions have two positions dedicated to technology infrastructure and device repair and maintenance. Division A has an additional ITRT position. Both divisions have a position in charge of PowerSchool (a student data management system), however Division A has a separate position for state reporting, whereas Division B has only one position responsible for both PowerSchool and state reporting.

Table 16

Number of Technology Staff Positions

Quote	Code	Transcription Line
We have [a] computer technician, me still doing computer technician and network administration, and then we have [one person who oversees] PowerSchool... and then we have [one person who oversees] our state reporting.	AP1	478-480
So I've got four other members. Two are on the technical side. One does network admin and the other one is tech support. We all do tech support. And we all, we all do everything. I will go into classrooms myself and do stuff when we need to. And then I've got two other folks that do state reporting and PowerSchool support.	AT1	258-261
Six, including [the Director of Technology], right?	BP3	264
[Two ITRTs, the Director of Technology and two Technology Specialists].	BP2	265
[One person], she does handle PowerSchool and a lot of the applications that we support with PowerSchool, [and state reporting].	BP3	269-270
There are a total of six people in the technology department. Two of those folks are strictly instructional. Two of them are in charge of desktops, printers, kind of all the physical hardware that we do as well as software to support all four buildings. And then our, the last person aside from myself, is in charge of data and state reporting.	BT1	270-274

The information shown in Table 17 provides an overview of respondents' perceptions of whether additional technology personnel are needed in their division. The table reveals major differences between Division A and Division B. The director of technology and the technology personnel from Division A, who already began a one-to-one Chromebook initiative, did not agree in their responses. The director of technology of Division A felt they had an appropriate number of staff to handle their current workload based on the contracting out of broken Chromebook devices to a third party company (as opposed to completing broken device repairs in house). This is in contrast to a technology staff member from Division A, who stated their belief for a need to have one technician per building within the division. The director of technology and technology personnel of Division B were both in agreement that they currently did not have enough staff members to be able to adequately handle their current need for repairs, maintenance, and upgrades to technology infrastructure within the division.

Table 17

Additional Technology Staff Positions

Quote	Code	Transcription Line
I don’t think we do. I would like to see one technician per school, we've always wanted that.	AP1	489-490
Right now we're pretty good. Right now we use TIG as a pickup repair service for one-to-one [Chromebook devices].	AT1	264-265
No. [The PowerSchool/state reporting position] needs an assistant, or at least a helper. I mean she's one person doing data for all the schools, which is a chore.	BP1	274-276
We could definitely use an additional technology staff person. Someone with a background that can handle multiple roles that we each do.	BP3	277-278
We do not have the people on staff necessary to really get done everything we want to get done, in the timeline we want to get it done.	BT1	284-285

Research question 2. What physical components, equipment, and personnel are necessary for adequate facilities infrastructure to support technology initiatives?

Table 18 defines the interview responses regarding the structural components necessary to develop facilities infrastructure within a school system. These responses developed three separate themes as discussed by more than one respondent; switches, fiber for switch closets, and wireless access points. Terminology varied depending on the respondent, however the same features were discussed. Respondent BP3 referred to wireless access points as “access points” (transcription line 142). Respondent AP1 referred to the same component as an “air hive” (transcription line 171). Respondent BT1 discussed the need to have fiber run to MDF’s and IDF’s.

Table 18

Major Structural Component Requirements

Quote	Code	Transcription Line
Replacement of our main servers and our switches. I think those are the biggest two.	BP3	7-138
We went to 1 gig switches... and we're moving toward more virtual machines instead of buying separate servers we can buy one server and run numerous virtual servers off of that one.	AP1	151-153
We need switches that... support gigabit throughput.	BT1	144-145
Access points.	BP3	142
We actually put in more air hives.	AP1	171
Ultimately we need fiber connections from every MDF to every IDF.	BT1	143
A good network design with a hub and spoke model, central distribution with your nodes on the outsides is a good method.	AT1	132-133

"The main communications room in a building is known as the Main Distribution Frame or MDF. MDF facilities provide the initial connectivity point between the building and the campus" (Montgomery College, 2009, p. 10). "The communications rooms in a building that serve a specific floor or section of a building are known as Intermediate Distribution Frames or IDF's" (Montgomery College, 2009, p. 11). Respondent AT1 also discussed this component, however, the response was given using the terminology hub and spoke. "In a Hub-and-spoke Site-to-Site Wide Area Network (WAN) network topology, one physical site act as Hub (Example, Main Office), while other physical sites act as spokes. Spoke sites are connected to each other via Hub site" (omnisecu.com, 2008, para. 2). Switches, switch closets (with their need for a fiber connection), and wireless access points were the major components all four interviews discussed as necessary for operating and maintaining each division's currently planned technology initiatives.

Table 19 represents answers regarding whether or not respondents felt their school division had the necessary structural components and equipment in place to implement it's currently planned technology initiatives. These data outline two different responses between Division A and Division B. Division A indicated in both the individual and focus group interviews there were no, or very few, components that were not already in place. In contrast to

Division A, Division B indicated they did not have the components necessary to implement its currently planned technology initiatives.

Table 19

Perceptions of Structural Component Needs

Quote	Code	Transcription Line
I think in general all of our needs are being met.	AP2	227
So for here, it's basically just watching the bandwidth at [one of our elementary schools] a little more closely.	AT1	169-170
No.	BP1	148
No.	BP3	148
We definitely don't have the structural components in place at this time.	BT1	171

Table 20 displays responses defining what specific structural components were still needed for facilities infrastructure to support technology initiatives within each division. Division A’s lone response stated more bandwidth would need to be addressed within their buildings. Division B responses indicated major areas of focus for adding and upgrading components were switches, wireless access points, server replacement, and additional bandwidth.

Table 20

Additional Structural Components Needed

Quote	Code	Transcription Line
I think everybody wish we had more bandwidth.	AP2	228
We’ve got to go talk to Cox and up the rate to get a higher bandwidth.	AT1	161-162
We will be purchasing new switches.	BP3	158-159
Right now, our Wi-Fi in our schools can't handle that many Chromebooks for every student.	BP1	161-162
And we plan to beef up, or add to the access points.	BP2	164
On the back end, we also are looking at replacing our servers.	BP3	167
We've increased the bandwidth at the high school and we're in the process of increasing the bandwidth for the at the middle school which will feed into all three schools.	BP3	182-183
We need to cable in the classrooms so we can put in an access point in every classroom.	BT1	175-176
We need to increase the internet, the overall internet speed.	BT1	178

Table 21 displays responses pertaining to work contracted out to third party companies. This data revealed two major themes. Responses from Division A indicated that division technology personnel could complete the majority of technical infrastructure installation, maintenance, and repairs. Items that could not be handled by division personnel included highly specialized work such as fiber installation or advanced networking, or high volume work such as Chromebook device repair. This contrasted with the responses from Division B, stating much of the acquisition and installation of infrastructure components fell to outside contracted companies. Configuration of routers and core switches, hardware and software acquisition, cabling, and security systems were all items contracted out to third party companies. Respondents from Division B stated these components could not be installed due to lack of time, experience, and/or skillset on the part of division technology staff.

Table 21

Needs for Outside Contracting

Quote	Code	Transcription Line
When our Chromebooks are completely broken I know that is outsourced.	AP4	530
The only thing that we really have to contract out probably would be fiber.	AP1	543
Some of the advanced networking I do have contracted out.	AT1	281-282
We did our upgrades and configurations of our router and core switches where outsourced.	BP1	283-284
A lot of our hardware I know we use an outside vendor to purchase hardware from because they can often times suggest what equipment is the best equipment to use, software, hardware-wise.	BP3	164
And wiring. That's also an outside because that's a pain getting up there and getting in the ceilings.	BP1	293-294
And then our security cameras and system is outsourced. We don't have technology staff with that skill set.	BP3	295, 298

Table 22 presents findings related to training and professional development opportunities for technology personnel in Division A and Division B. Responses from both divisions were similar. Both divisions do not have formalized training and professional development programs. They rely heavily on background knowledge and prior experiences of technology personnel, self-investigation through technical manuals and internet-based searches, and collaborating with other technology personnel within the division to troubleshoot and problem solve when issues arise.

Table 22

Opportunities for Technology Staff Training

Quote	Code	Transcription Line
We sent [the person who oversees PowerSchool] to PowerSchool Academy and got her certified with PowerSchool.	AP1	549-550
We are sent to conferences.	AP3	557
[The Director of Technology] sent me back to school again, J Sargeant Reynolds, last year for a whole year to do Cisco routing.	AP1	537-538
We don't have any like set, like programs or procedures. I wanted to get everybody in the same place so we could do, we're all doing the same thing, we're all doing cross-training if they need help and things they haven't tackled yet before. It's more inter-departmental training, if anything. I have some discretionary money, as far as PD, within the department that I can use for that if there was a hole that I felt we couldn't cover with our basic stuff. They are supportive of us doing that.	AT1	294, 296-297, 312-313, 317-318
Most of these guys are self-learned. I mean, they investigate, and find the answers themselves.	BP2	309-310
Conference here and there, you know, sometimes to conferences.	BP3	311
Newsletters of the newest and best technology and plans to use it.	BP1	312
We do very little formal training for the technology staff. Thankfully the team is self-starters, which is huge.	BT1	310, 317

Table 23 displays the responses pertaining to factors necessary for maintaining facilities infrastructure that were not already discussed during each interview. Division A had a singular response focused on a new Superintendent and how this influenced the direction of technology initiatives. Division B responded with an overall theme of communication. Three separate respondents cited a need for communication between the technology staff and the operations manager, the public, and other school staff.

Table 23

Other Factors Not Discussed in Maintaining Infrastructure

Quote	Code	Transcription Line
Well I think some of our initiatives were pushed forward based on the fact when we acquired a new superintendent.	AP3	567-568
He came in and made sure that everything was wireless.	AP2	569
He really did a lot to push some of these initiatives forward despite the fact that he didn't have enough money at the time.	AP3	571
He was younger and he came from a school division that was on par versus the ladder that was a little old school.	AP1	572-573
I don't think so.	AT1	325
Just talking, especially with operations managers.	BP1	317
I think, getting the facts out to the public are important.	BP2	321
I would say just communications between school and staff members.	BP3	327

Research Question 3. What are the perceived infrastructure barriers to effective integration of technology in a school building?

Table 24 outlines respondents' perceptions of barriers to developing facilities infrastructure to support technology initiatives within their school division. Three major barriers were identified. The first barrier was funding, the largest response regarding barriers to technology infrastructure. Funding is the only theme that was discussed in all four interviews. Many of the respondents felt that funding was an issue as school and division leaders do not always understand technology and its changing needs even though they often make decisions regarding technology funds. One respondent highlighted their belief that the high cost for many technology infrastructure components, which are rarely, if ever, seen by division leadership or other stakeholders, can often create a barrier. A second identified barrier was size of the technology team. This could be a barrier to technology personnel completing all of their necessary job functions, mainly through lack of time to complete tasks. The third barrier was electrical outlets. Several respondents stated that in older buildings, electrical outlets were not sufficient to meet the need of the high number of student devices that required recharging periodically throughout the school day.

Table 24

Perceived Infrastructure Barriers

Quote	Code	Transcription Line
We in our department would like to see one-to-one with all the schools but it's funding… and I know money is always tight.	AP1	247-250
It's always about the money.	AP3	251
Our biggest hurdle is the leaders themselves. And our individual buildings don't readily integrate technology themselves.	AP3	274-275
Our rooms, even if they're only 15 years old, we don't have many electrical outlets in our rooms, which, is so hard.	AP4	402-403
[At one] elementary school, because it was an open school, they put up the walls and we have trouble with electrical outlets.	AP3	405-406
Some people balk at a $50,000 cost tag on something that nobody's ever going to see and most end users aren't going to see a difference in performance on a network switch or stacks or whatever, but it gave you the flexibility to then go in throw however many A.P.s you wanted to increase your Wi-Fi coverage, or the ability to get faster connection point down to the desktop.	AT1	196-199
Funds.	BP2	191
Well, of course, cost is a huge piece.	BT1	192
We don't have a large technology department. And so implementing a lot of the switch installs, for example, become very problematic because we also have very outdated computers, printers, peripheral devices, everything you can imagine in this district is incredibly outdated, and needs service all the time.	BT1	193-196
We don't have the capability in house to do some of the router programming and some of the higher end switch programming that's necessary to bring that in. So that's something that we have to contract out, which ends up being higher cost.	BT1	199-201

Table 25 shows the age (or approximate age) of each school building in Division A and Division B. These data demonstrate an opposite relationship between the ages of the school buildings serving younger and older students in the two divisions (example: Division A's lower schools were their oldest, while Division B's lower schools were their newest). However, there are a consistent number of years separating each of the four buildings in Division A and B.

Table 25

Age of School Buildings

Division A		Division B	
Level of School	Age (in years)	Level of School	Age (in years)
Elementary School 1	84	Elementary School 1	14
Elementary School 2	≈ 40	Elementary School 2	28
Middle School	≈ 15	Middle School	66
High School	9	High School	92

Table 26 organizes respondents' perceptions as to whether or not the ages of the school buildings in their division support or impede facilities infrastructure for technology initiatives. Respondents in all but one interview made statements that older buildings impeded their ability to develop and/or maintain its infrastructure. An issue pertaining to Wi-Fi signal in older buildings was the most common theme from respondents. This was due to construction materials such as steel and concrete, and building designs that created less ability for Wi-Fi signals to penetrate through walls. Also with older buildings, the necessary cabling and number of drops needed for wireless infrastructure were not in place when the buildings were originally constructed to meet current needs. This necessitated additional personnel, money, and build out times. Funding to meet the need of higher costs associated with older buildings was also an issue addressed by one respondent. Only one respondent stated their perception that the age of the building did not impede technology infrastructure.

Table 26

Age of School as a Support or Impediment to Infrastructure

Quote	Code	Transcription Line
But as for technology infrastructure and some of the older buildings, the only thing I see it affects is money because to go behind something that is that old and renovate, but they've all been renovated, they've all got fiber and everything like that, so now that's not really an issue.	AP1	433-436
It depends on the age of the building. The historical school had limits only because it was an asbestos filled building that would need abatement, and would be super expensive, and you're doing all the cabling in the hallways, which is super unattractive, and nobody wanted that type of environment. So, historical buildings hold an innate problem in fixing and getting technology into them because there isn't a Wi-Fi solution that doesn't need backbone infrastructure.	AT1	213-218
I would say impede in some cases. Such as with access points, the way the buildings are designed, the signal for those access points sometimes can't, until we went to the one-to-one in every classroom, they were previously in the hallways, so, inside some classrooms they couldn't get Wi-Fi signals.	BP3	199-202
[One of our elementary schools], which is the newest, doesn't really have that issue. But the middle school, it's a lot of concrete and steel. And signal just does not want to go through, between room to room.	BP1	208-210
I know at the high school, and maybe some of the middle school too, the buildings were initially designed to have one drop per room. Obviously one drop per room can only handle one computer.	BP3	226-228
The age of the buildings don't really affect what we need to do.	BT1	210

Table 27 outlines other barriers to implementing technology infrastructure that were not discussed previously in the interviews but were important for the respondents to discuss. Two of the interviews yielded no response. The other two interviews discussed funding as major barrier to technology infrastructure. One respondent indicated that even though money is allotted for technology, that money can often be diverted elsewhere for other needs, pushing out planned technology infrastructure projects to future years.

Table 27

Other Barriers Not Discussed

Quote	Code	Transcription Line
I don’t know, when I read that, all I can think of is money barriers.	AP1	580
Nope, nothing that we haven't covered.	AT1	345
I can't think of any that we haven't discussed.	BP2	340
Funding is one of the biggest things.	BT1	352

Review of Documents

A review of documents for both Division A and B was completed to acquire additional data regarding both divisions technology plans, any information pertinent to a major technology initiative or program such as a one-to-one device initiative, and figures outlining budgets for technology and facilities infrastructure (see Table 28).

Table 28

Review of Documents

Division A	Division B
Document Name	Document Name
6-year Strategic Plan	Comprehensive 6-year Plan
Technology Plan	Website
Division Website	School Board “Board Docs” Website
School Board “Board Docs” Website	2014 One-to-one Device Memo
FAQ Digital Conversion Flier	One-to-one Device Proposal (version 1)
Digital Conversation Website	One-to-one Device Proposal (version 2)
Superintendent's Budget Presentation FY15-16	Approved Budget for Fiscal Year 15-16
Superintendent's Budget Presentation FY17-18	Approved Budget for Fiscal Year 17-18
	Superintendent's Budget Presentation FY15-16
	Superintendent's Budget Presentation FY17-18

A review of technology documents for District A revealed their six-year strategic plan to include a section dedicated to technology. Technology was listed as vision statement seven in the strategic plan, which stated Division A “would utilize technology to enhance the instructional opportunities for students, support instructional strategies for teachers, and supplement technology availability for the community" (Division A strategic plan). This vision was divided into goal statements A, B, and C. Goal statement A outlined the provision of technology infrastructure, hardware, software, and personnel necessary to support and administer an effective educational program, consistent with the division's technology plan. Goal statement A was then broken down into four sections. Section one stated a technology procurement and replacement plan would be developed, adopted, and funded to meet the instructional and operational needs of the division. Section two stated wireless technology accessibility would be expanded in all schools to provide more accessibility options for staff and students. Section three stated new technologies would be implemented that would support energy and cost savings initiatives. Section four stated technology maintenance staff would be expanded to accommodate the needs presented as new technologies are deployed and to allow for better maintenance of the student information management system.

Goal statement B discussed providing professional development staffing and opportunities to teachers that would enable them to appropriately utilize the technology that is available to them. Goal statement B was then broken down into two sections. Section one stated a full-time technology teacher and ITRT would be employed for each school. Section two stated each school would organize and utilize a technology committee to explore new technology, identify technology needs, and provide professional development for other staff in the school.

Goal statement C reviewed the exploration and implementation of emerging technologies to enhance learning opportunities and increase accessibility for students. Goal statement C was then broken down into two sections. Section one stated virtual course offerings would be explored and piloted to provide students with more course options across a more diverse selection of instructional settings. Section two stated Bring Your Own Technology models would be explored and piloted for implementation in middle school and high school.

One page on Division A's website outlined its "digital conversation", which was a communication platform with Division A's community stakeholders prior to implementing a one-to-one initiative. The webpage states that Division A planned to provide teachers and students with a greater access to technology during the 2015-16 school year. As a part of the process, Division A installed wireless networks in all four of their school buildings. They provided a Chromebook to all middle school and high school students and teachers. A separate flier was obtained which outlined the major components of the “digital conversation”. The flier stated that in addition to middle and high school students receiving devices, all elementary school students would receive devices at a 3:1 student to Chromebook ratio. An additional website was created to house technical and troubleshooting assistance to students and parents. This website included quick FAQ guides, as well as pictorial and video troubleshooting assistance.

An extensive review of the Division A’s website, including its page for instruction, finance, school board, the external Board Docs website (which houses all school board documents), and technology (which does not exist), returned incomplete budget information. As shown in Table 29, budget information for Division A was obtained for the 2015-16, 2016-17, and 2017-18 school year. The only budget information available on the division’s website was the current 2017-18 school year budget. The remaining budget information used in the review of documents for this study was found through a general “Google search” to locate prior year budget presentations for Division A.

Table 29

Division A Technology Budget Information

School Year	2015-16	2016-17	2017-18
Technology Funds Budgeted ($)	1,131,397	1,417,985	1,467,349
% +/- from Previous FY	-	20.2	3.4
% of Overall FY Budget	3.9	4.6	4.5
Total Operating Budget ($)	29,046,106	30,916,241	31,000,145
Technology Hardware/Infrastructure Expenditures ($)	357,340	598,000	598,000

During a review of technology documents for District B, it was discovered that the 2013-2019 comprehensive 6-year plan for Division B stated that a technology plan was one of the areas addressed within the comprehensive plan, however, no technology plan, nor any directions to an attached external document existed. The comprehensive plan did outline a projected capital improvements plan. The capital improvement plan allotted funding for major projects such as HVAC replacement, cooling tower replacement, security camera installation, exterior light installation, demolition of an unused building, construction of a new school, however, no major projects were funded to improve the technology infrastructure at any of the four schools.

In August 2014, the assistant superintendent of instruction for Division B sent the school board a memo outlining a request for a one-to-one device initiative. The plan originally called for provision of devices to a small group of seniors in the fall of 2015 or 2016, with the plan to provide a device to all seniors during the following school year. The plan also called for provision of a device to all middle school students in the fall of 2015 or 2016, and the following year, provide a device to all ninth graders. The plan called for the addition of devices to one grade level each subsequent year until all students in grades 6-12 had devices.

In February of 2015, the initial version of a one-to-one Chromebook device proposal was submitted at a school board meeting for Division B. The proposal stated that many discussions and meetings with other counties had been held since 2014 to discuss the pros and cons of their one-to-one initiatives. The proposal reviewed the current research literature on these types of initiatives. Based on the research completed by the division, Chromebooks had been determined to be the device of choice for this initiative. This proposal changed the device distribution method from the 2014 memo. The February 2015 proposal suggested implementing the one-to-one initiative in grades 7-10.

The plan was to keep computers in circulation for three years. After the three years, if the device was still functioning, it would be filtered to the sixth grade, as well as the elementary and primary schools as class sets. Students would carry the same Chromebook with them in the 7th, 8th and 9th grades. In the 10th grade, students would receive a new Chromebook to carry with them through 12th grade. During year two of implementation, starting fall of 2016, old 9th grade laptops would be moved to 12th grade, completing the one-to-one initiative in grades 7-12. The only verbiage related to facilities infrastructure was a one line explanation that the next step was to bring in the IT team to discuss the budget and technical side of a one-to-one initiative.

An updated version of the same proposal was submitted to the school board of Division B in August of 2016. The same method for disseminating Chromebooks to students was in place as in the 2015 proposal, however, with a delayed timeline to begin during the 2016-17 school year. The only information pertinent to facilities infrastructure found in the updated 2016 proposal was a short narrative stating computer technicians were in the process of making sure the network and infrastructure was in order so every classroom in grades 7-12 would be able to access the network and Internet, without crashing the system.

According to the superintendent's proposed budget presentation for the 2017-18 school year for Division B, a request was made to hire an additional technology specialist to streamline repair and replacement of instructional computers. This position was stated as a need for the rollout of the one-to-one initiative at the high school during the 2017-18 school year; however, this position was not funded for the 2017-18 school year. The model to roll out Chromebook devices beginning only at the high school was an additional change in the planned dissemination of Chromebooks to students, and also the second year of delaying the start of the initiative.

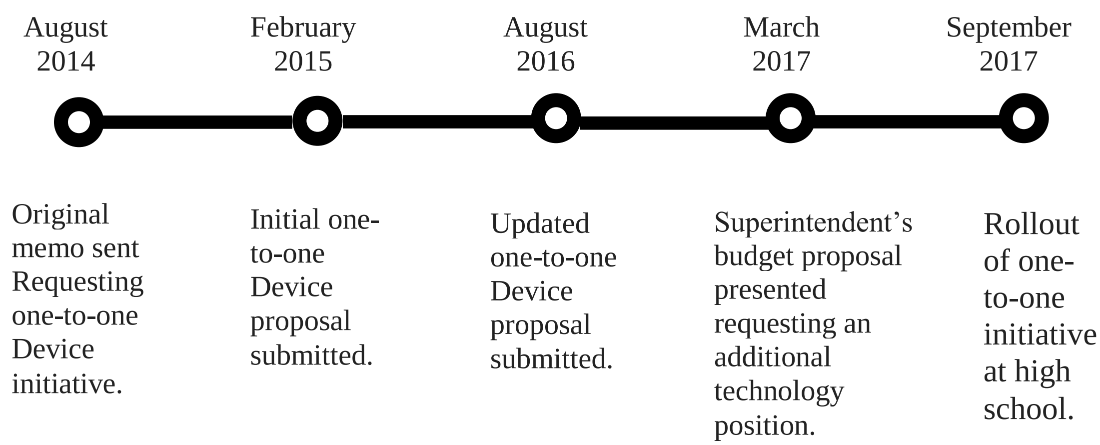

Figure 2. Timeline of Division B's rollout of one-to-one device initiative.

A review of Division B's website, including its technology page, finance page, school board page, and external Board Docs website (which houses all school board documents) returned incomplete budget information. As shown in Table 30, budget information for Division B was obtained for the 2015-16, 2016-17, 2017-18, and proposed 2018-19 school years (technology hardware and infrastructure expenditure figures for the 2016-17 school year was unable to be obtained). Web pages on the division website were not up to date or did not offer comprehensive links to previous school year budget information. The remaining budget information used in the review of documents for this study was found through a general "Google search" to locate prior year budget presentations for Division B.

Table 30

Division B Technology Budget Information

School Year	2015-16	2016-17	2017-18	2018-19 (proposed)
Technology Funds Budgeted ($)	868,690	878,494	901,640	1,235,210
% +/- from Previous FY	-	1.1	2.6	28.9
% of Overall FY Budget	3.6	3.5	3.6	4.8
Total Operating Budget ($)	24,288,180	24,918,180	24,654,500	25,843,440
Technology Hardware/Infrastructure Expenditures ($)	184,800	194,530	NA	173,000

Note. NA indicates information was Not Available.

Summary

After analyzing the data, there were several similarities and differences between the responses from Division A and Division B.

Planning. The consensus among respondents was the five-year state mandated plan was not sufficient or representative of the division's current technology needs. Respondents felt the five-year state plan did not afford the ability to remain flexible and constantly make changes to the technology needs of the division. All respondents indicated each division maintains a less formalized technology plan that evolves constantly to keep up with the changing needs of the division's technology initiatives. These plans are frequently reviewed and updated based on formal and informal meetings of technology staff members. The major difference between long-term and short-term planning was that the long-term five-year state technology plan was essentially a document for public consumption, while a short-term, internal technology plan was constantly revised and updated to meet the changing technology needs of the school division.

Prioritizing initiatives. Regarding the prioritization of major technology initiatives, a one-to-one Chromebook initiative was the overwhelming response from all four interviews as a priority for the technology teams. Directors of Technology who were interviewed indicated central office administration and the school board were most influential in determining the focus of division-wide technology initiatives. Technology staff responses were focused on the components necessary to maintain technology infrastructure.

Technology staff size. An interview question was posed to the respondents to determine whether or not the technology staff in place within each division was adequate to meet the needs of maintaining technology infrastructure. There were varied responses between Division A and Division B. The director of technology of Division A felt they currently had an appropriate number of staff to handle their current workload based on the contracting out of broken Chromebook devices to a third party company (as opposed to completing broken device repairs in house). This contrasted with a technology staff member from Division A who stated their preference for a need to have one technician in each building in the division. Division B, who is just beginning a one-to-one Chromebook device initiative, had an aligned response from both the director of technology and technology staff. Both respondents stated they currently did not have enough staff members to be able to adequately handle their current need for repairs, maintenance, and upgrades to technology infrastructure within the division. Staff in Division B also indicated a need for skill flexibility in a new position.

Major structural components. Three separate topics were discussed by more than one respondent as major structural components necessary to implement currently planned technology initiatives; switches, fiber for switch closets, and wireless access points. Interviews captured two different responses between Division A and Division B regarding structural technology components already in place. Division A indicated in both the individual and focus group interviews that there were no, or very few, components that were not already in place. By contrast, Division B indicated that they did not currently have all the components necessary to implement its currently planned technology initiatives.

Even though respondents from Division A felt they had the necessary structural components in place at this time, there was still more than one respondent who indicated that more bandwidth would need to be addressed. Division B had a wider range of answers, as noted by responses indicating fewer structural components were currently in place than in Division A. Major areas of focus for adding/upgrading components in Division B included switches, wireless access points, server replacement, and bandwidth.

Responses from Division A indicated that the majority of technical infrastructure installation, maintenance, and repair were kept in house and completed by division technology staff. This contrasted sharply with the responses from Division B, stating much of the acquisition and installation of technical infrastructure components fell to outside contracted companies due to lack of time, experience, and/or skillset of division technology staff.

Professional development. Both divisions reported they do not have formalized professional development or training programs. Some out-of-division classes and conferences are available, but not commonplace, in both divisions. Both Division A and B rely heavily on background knowledge, prior experiences of technology staff, and self-investigation to troubleshoot and problem solve when issues arise. Reliance upon other technology staff members is also important in troubleshooting issues.

Other factors. When asked about other factors or information not already discussed in the interview that would be important to know about how their school division builds/maintains its school facilities infrastructure to support technology initiatives, Division A responded with a focus on a new Superintendent and how this influenced the direction of technology initiatives. Division B responded with an overall theme of communication. Three separate respondents cited a need for communication between the technology staff and the operations manager, the public, and other school staff.

Barriers to technology. Based on data from the conducted interviews, barriers to implementation of technology infrastructure can be organized into three major themes. The first theme, funding, received the most attention from respondents regarding barriers to technology infrastructure. This is the only theme that was found to be a response in all four interviews. Many of the respondents felt that funding was an issue as school and division leaders do not always understand technology and its changing needs even though they often make decisions regarding technology funds. One respondent highlighted their belief that the high cost for many technology infrastructure components, which are rarely, if ever, seen by division leadership or other stakeholders, can often create a barrier.

A second theme was the size of the technology team could be a barrier to completing all of their necessary job functions, mainly through lack of time to complete tasks. The final theme was electrical outlets. Several respondents stated that in older buildings, electrical outlets were not sufficient to meet the need of the high number of student devices that require recharging periodically throughout the school day.

Respondents revealed the school buildings serving upper and lower grade level students in Division A and B were of opposite ages (example: Division A's lower schools were their oldest, while Division B's lower schools were their newest). However, there were a fairly consistent number of years separating each of the four school buildings in Division A and B.

Respondents in three out of four interviews made statements that older buildings impeded their ability to develop and/or maintain its infrastructure. An issue with the Wi-Fi signal in older buildings was the most common theme from respondents. This was due to construction materials which created less ability for Wi-Fi signals to penetrate through walls. Cabling and the number of drops needed for wireless infrastructure was also not in place when the building was originally constructed to meet current needs. Funding was an issue addressed by one respondent. Only one respondent stated their opinion was that the age of the building did not impede technology infrastructure.

Respondents were also asked what other barriers to implementing technology infrastructure were not discussed previously in the interview but were important to discuss. Two of the interviews yielded no response. The other two interviews discussed funding as major barrier to technology infrastructure. One respondent indicated that even though a budget can be allotted for technology, that money can often be diverted elsewhere for other needs, pushing out planned technology infrastructure projects to future years.

Review of documents. In a review of documents for Division A and Division B, it was discovered that both divisions maintained a long-range plan. Division A set specific vision and goal statements for technology in their long-range plan. Division B stated a technology plan was a part of their long-range plan under the table of contents, but no such plan existed in the document. For both Division A and Division B, few public documents exist outlining the planning and roll out of their one-to-one device initiatives. Budget documents for both divisions were also not easily accessible via the division website and external school board (Board Docs) website. A general “Google search” yielded most of the public budget presentation documents used for the analysis of this study.

Chapter 5 outlines the primary findings of this study and how this study reflects the literature on facilities infrastructure to support technology initiatives in rural school divisions. Chapter 5 also presents the researcher’s findings, implications, and recommendations for further research.

CHAPTER FIVE
FINDINGS AND CONCLUSIONS

Summary

The purpose of this study was to determine the planning and implementation practices necessary for facilities infrastructure to support technology initiatives in two rural school divisions in Virginia. Research in the field of school facilities infrastructure to support technology indicates there is no consensus for how to build infrastructure to support technology initiatives (Arnold, 2014; Lu et al., 2015; Vidoni, 2004). This study sought to collect data from the knowledge and experiences of technology leaders and their personnel to better understand the needs, barriers, and best practices in developing and maintaining school facilities infrastructure, an area of relatively little study in academic literature. The three research questions addressed in this study were:

1. What short-term and/or long-term plans are in place for building and maintaining facilities infrastructure to support technology initiatives?
2. What physical components, equipment, and personnel are necessary for adequate facilities infrastructure to support technology initiatives?
3. What are the perceived infrastructure barriers to effective integration of technology in a school building?

A qualitative methodology was selected for this study as it provides an understanding of the infrastructure needs to support technology initiatives in a rural school setting. A multiple case study design, focused on interviewing two separate school divisions, was then triangulated with a review of documents to provide the most in depth and wide ranging data to support the case study design. The researcher conducted an individual interview with the director of technology in both school divisions, as well as a focus group interview with both technology teams.

Findings

The findings from this study were based on data collected from individual and focus group interviews, as well as a review of documents related to planning, budgeting, and implementing technology initiatives for Division A and B.

Finding one. Although school divisions are mandated to complete a five-year state technology plan, it is not the document that defines a school division's technology goals and initiatives.

Respondents to this study indicated that the mandated five-year technology plan is essentially a formality and a document for public consumption (see Table 12). A more informal technology plan is developed within the technology team. This informal plan is reviewed and revised regularly (see Table 13). Regularly refers to a period of time more frequent than the five-year state technology plan, anywhere from six months to weekly, depending on the frequency and scope of the technology needs. This informal plan is most often designed based on formal and informal meetings between senior division leadership, the technology team, and feedback from other division stakeholders (particularly teachers). This aligns with research that indicates the constantly changing state of technology makes it difficult for a five-year plan to remain current and effective. Culp et al. (2005) also noted it is difficult to outline a single, clearly defined set of goals for educational technology integration because of the following:

- Technologies themselves are multiple, implying different strategies of use and application;
- Technologies themselves are evolving rapidly, often far faster than schools are able to change their practices or even their purchasing plans;
- Local, state, and federal policy and budgetary environments in which schools are working are also in constant flux, making sustained investment and development difficult;
- Public perceptions of the proper role for new technologies in K-12 education continue to evolve (p. 299).

Finding one is directly related to research question one regarding planning for facility infrastructure to support technology initiatives.

Finding two. One-to-one device initiatives are major technology initiatives that require planning of time, resources, personnel, and funding.

Respondents indicated during interviews that the priorities for their division's technology plan, recently a decision to implement a one-to-one device initiative, were typically driven from the school board and/or central office administration level (see Table 15). In both cases, the initiative was begun at the high school level and then phased into lower grade levels over subsequent years until full grade level saturation was reached. It was also stated the major priorities technology staff focused on were servers and switches, as well as developing backup redundancy. This is supported by research as Arnold's (2014) dissertation noted the importance of the decisions made by school division supervisory leadership to the success or failure of integrating ICT resources.

Division A and B gave completely contrasting responses regarding the current state of their division's facilities infrastructure (see Table 19). Division A is in year three of implementation of a one-to-one device initiative and had previously created a plan to upgrade their infrastructure to accommodate the demands of such an endeavor. Division B has not planned for and invested in their facilities infrastructure in the same way. Respondent BT1 stated, "historically, since 2008, [our division] has not invested in infrastructure or improvement or development of facilities. All four of our buildings are in rough shape. All of our equipment somehow is still working, it's all past end of life" (transcription line 33-37). Respondent BT1 explained why all of their equipment is past their end of life. "When I came on board, we had no plan to replace any equipment" (transcription line 66-67). This is supported in the research. Dell Incorporated (2006) noted that once IT infrastructure has been put into place, it must also be regularly serviced and upgraded to retain adequate performance. IT infrastructure that comprised aging and had varied technology platforms inhibited technology's effect on student achievement and long-term success of technology platforms and programs. Dell Incorporated (2006) also stated that it is not an advised practice for organizations to use equipment nearing the end of its life cycle.

A factor in Division B's inattention to its facilities infrastructure is due to funding. Table 28 and Table 29 outline the disparity in funding between Division A and B. In the three fiscal years of operation between 2015 and 2017, Division A spent three times more than Division B on their facilities infrastructure for technology. During the same three-year period, Division A allocated $1.6 million more than Division B for their overall technology budget. This is while both divisions were planning to implement a one-to-one device initiative beginning in 2015. However, Division B was unable to begin their initiative until the 2017 school year, due to lack of funding and facilities infrastructure upgrades to adequately operate such an initiative. Lack of funding for technology was a prominent theme in the research. The pressure on school divisions from underfunding is felt most severely in rural divisions. According to Schwartzbeck (2003), rural school divisions often have fewer community-based resources donated to them and heavily depend on government resource support. Finding two is directly related to research question one regarding planning for facility infrastructure to support technology initiatives.

Finding three. Servers, switches, wireless access points, and fiber connections to server closets are the major structural components necessary to implement a division's currently planned technology initiatives.

Of all structural components necessary to implement a division's technology initiatives, servers, switches, wireless access points, and fiber connections to server closets were the only items addressed by multiple respondents in every interview (see Table 18). However, the way in which respondents in each interview named the components varied. The importance of servers, switches, wireless access points, and fiber connections was supported in the research by Harris (2014) who stated, "equipment such as wireless hubs and specialized fiber optic cable are needed to utilize technologies such as laptops and electronic whiteboards, and to promote twenty-first century learning". Not only are these components important to have, but also according to 3Com Corporation (2010), many school divisions across the United States suffer from a lack of uniformity with hubs, switches, and devices resulting in a network with performance issues that are difficult to troubleshoot. Finding three is directly related to research question two regarding the physical components, equipment, and personnel necessary for adequate facility infrastructure to support technology initiatives.

Finding four. Technology personnel do not feel they have an adequate number of positions to handle the scope of their work.

Technology staff for Division A and B outlined a very similar structure regarding the make-up of their technology teams (see Table 16). Both had two personnel positions in charge of infrastructure. Division A had three ITRT positions, while Division B had two. Division A had separate positions for PowerSchool and state reporting, while Division B had one position for both responsibilities. All technology personnel were in agreement they did not have enough technology infrastructure support staff and ITRT positions to meet the needs of their department (see Table 17). The need for additional positions in order to gain flexibility to handle multiple types of issues was also addressed. The research regarding technology staffing aligns with this as Hawkes, Halverson, and Brockmueller (2002) explained that for many rural school divisions, maintaining and facilitating this equipment is just as difficult as acquiring it. IT equipment requires a local pool of technology professionals who are capable of fulfilling school division needs for information technology integration (Hawkes et al, 2002). Finding four is directly related to research question two regarding the physical components, equipment, and personnel necessary for adequate facility infrastructure to support technology initiatives.

Finding five. The amount of outsourced work from a division's technology department is related to the knowledge and skillset of the technology personnel.

Division A and B greatly differed in their responses as to how much work was contracted out to third party companies (see Table 21). Division A stated that very little work was contracted to third party companies outside of the division. Division technology staff could complete most infrastructure installations, repairs, and routine maintenance. The few issues that were contracted out were high volume or specialty jobs such as Chromebook device repair or fiber cabling installation.

Division B had a much higher rate of contracting services out to third party companies than Division A. Most major structural components such as router configuration, core switch replacement, cabling, and new hardware acquisition were all outsourced. Respondent BT1 indicated the major reason for the high volume of outsourcing was predominately due to two factors. "Because of the complex nature of that programming piece, and also, the importance that it runs as expected. And really, we don't have a network engineer on site, which is why we can't do the programming, and really we just don't have the manpower to do the cabling" (transcription line 304-307).

Personnel skillsets and training, coupled with time constraints due to understaffing, were the two prevalent causes of outsourcing. These findings are consistent with the research that outlined for many rural school divisions, maintaining and facilitating technology equipment is just as difficult as acquiring it (Hawkes, Halverson, and Brockmueller, 2002). IT equipment requires a local pool of technology professionals who are capable of fulfilling school division needs for information technology integration (Hawkes et al, 2002). Unfortunately, sustaining these teams are costly and often beyond the financial reach of rural schools and divisions (Reilly, 1999). Finding five is directly related to research question two regarding the physical components, equipment, and personnel necessary for adequate facility infrastructure to support technology initiatives.

Finding six. Rural public school divisions do not have formalized training or professional development opportunities for their technology personnel.

Other than some small, specialized training opportunities like a community college course for credentialing, or a tutorial academy, very few opportunities exist for technology personnel to receive formalized on the job training (see Table 22). The majority of learning new strategies, techniques, and methods for troubleshooting and maintaining facilities infrastructure falls on technology personnel through self-discovery, trial and error, and/or relying on the background experiences and knowledge of their colleagues. Respondent BP2 stated, "most of these guys are self-learned. I mean, they investigate, and find the answers themselves" (transcription line 309-310). This is echoed in the research through Leutscher (2005), who stated many programs disallow the use of funds for ancillary items such as professional development training and support. Finding six is directly related to research question two regarding the physical components, equipment, and personnel necessary for adequate facility infrastructure to support technology initiatives.

Finding seven. Older buildings have more impediments to supporting technology infrastructure than newer buildings.

The older a school building is, the less likely it was designed to house the necessary electrical and wiring needs of today's modern school buildings (see Table 25 and Table 26). It is not uncommon for school buildings in rural school divisions to be 20, 40, even 60 years old and still be in use (Hansen, 1992; Ornstein, 1994, Rowand, 1999). Many of these buildings have been through one or more renovations since their inception, however there are still additional problems that technology teams run into that are not seen in new school buildings. The major issues stem from the cabling and componentry for wireless Internet access. "So, historical buildings hold an innate problem in fixing and getting technology into them because there isn't a Wi-Fi solution that doesn't need backbone infrastructure" (Respondent AT1, transcription line 217-218).

Older buildings constructed multiple decades ago were not equipped with the wireless infrastructure needs of today, simply because wireless technology did not exist back then. Retrofitting older buildings with the cabling and additional access points necessary for wireless connectivity is often difficult and costly. Materials in older buildings, as well as the style of construction, are also factors that can often limit or block wireless signals from arriving to their intended location within a building. “But the middle school, it's a lot of concrete and steel. And signal just does not want to go through, between room to room” (Respondent BP1, transcription line 210).

Research acknowledged that these barriers are commonplace as Chan (1996) discussed how new school buildings can accommodate the needs of current academic programs because they house the most recent and innovative technological needs. However, older school facilities that are considered obsolete cannot meet existing demands because of changes in mechanical and technological needs. School infrastructure inadequacies can be traced back to the 1950s when there was a need to build new schools quickly and cheaply due to rising student enrollment from post-WWII baby boomers (Tanner & Lackney, 2006). Finding seven is directly related to research question three regarding perceived infrastructure barriers to effective integration of technology in school buildings.

Finding eight. Barriers exist to the integration of technology infrastructure based on each division’s depth and attention to planning, upgrading, and maintaining infrastructure components.

Each division is uniquely different in the depth and breadth of barriers to successfully implementing technology initiatives, based on the current operating facilities infrastructure (see Table 24). Several issues came to the forefront when discussing barriers to facilities infrastructure integration. Funding was the biggest topic. This was directly linked to leadership, as many respondents felt technology budgets were underfunded due to individuals who control the budget allocation not understanding all that is involved with technology components. This was mainly because most technology operations are behind the scenes and not visible to the public eye, so they are often overlooked. Other themes included not having enough electrical outlets to meet the needs of one-to-one device initiatives, and undersized technology teams.

Research supported these findings as Dickerson and Ackerman (2016) stated that since the start of the [2000’s] recession, the funding for school facilities had declined. Another barrier is failure for both individuals and organizations to recognize the necessity for change (Zimmerman, 2006). According to Meeks (2014), when schools first started being wired with networks for computer use in the classroom, the computers were such power hogs that putting two in one classroom would trip the circuit breaker. In recent years, a basic consideration for all schools is to design methods for handling the power load associated with the numerous devices staff and students will be using (Thornburg, 2009). Finding eight is directly related to research question three regarding perceived infrastructure barriers to effective integration of technology in school buildings.

Finding nine. Two-way communication between school and community stakeholders should take place horizontally and vertically.

To ensure that an appropriate understanding of the needs for a division's technology initiatives can be appropriately planned, implemented, and maintained, open and transparent communication must take place among school and community stakeholders at all levels (see Table 23). According to Arnold (2014), to adequately and successfully implement new technology initiatives, superintendents should rely on facilities, instructional, and technology leaders within the division to work collaboratively to implement a large-scale technology initiative. This collaborative approach should also be extended to community stakeholders to have a voice in the development of technology initiatives. Finding nine is directly related to research question three regarding perceived infrastructure barriers to effective integration of technology in school buildings.

Implications

The findings of this study support research that school facilities infrastructure is a very diverse and rapidly changing segment of school divisions.

Implication one. School divisions should develop a technology plan that can easily be updated and incorporates stakeholders from multiple cross-sections of the division.

In addition to the mandated five-year state technology plan divisions are required to complete, each division's internal technology plan should be fluid to allow for regular changes as new needs and/or barriers occur. Vertical two-way communication between division leadership, such as the school board, superintendent, and director of technology, and faculty/staff about the division's technology needs can help prevent breakdowns and failures with a technology plan. The school division leadership team is instrumental in developing the vision and goals for technology initiatives. This action, or inaction, can weigh heavily on whether or not a school division can appropriate upgrade and maintain its facilities infrastructure to support technology initiatives. This implication aligns with finding one regarding long-term planning for technology initiatives.

Implication two. School divisions need to properly plan, budget, and staff for major technology initiatives, such as a one-to-one device initiative.

One-to-one device initiatives are a growing aspect of many divisions' technology plans. These initiatives need to be planned well in advance of their anticipated roll out date. Funding needs to be secured ahead of time to ensure that the appropriate number of technology personnel is available to implement and maintain the initiative. Funding also needs to be in place to ensure that the facilities infrastructure can handle the strain that initiatives, such as a one-to-one device initiative, will add. If divisions do not have the appropriate number and properly certified technology personnel on staff, additional challenges are created to develop and maintain facilities infrastructure to support technology initiatives. Failure to appropriately address these issues can create delays in the roll out of the initiative. It can also cause the initiative to not gain traction from school stakeholders, such as students, staff, and parents, because of frustration from an inefficient infrastructure preventing optimal device and program usage. This implication supports finding two outlining major technology initiatives, such as a one-to-one device initiative.

Implication three. School divisions should ensure proper installation, repair, and maintenance of major structural components.

Components such as servers, switches, wireless access points, fiber cabling, and appropriately planned and built server closets are critical for an optimized facilities infrastructure. The ability to create redundancy and an appropriate plan to replace core structural components should also be a priority for technology leaders to prevent key breakdowns and failures within the facilities infrastructure of a school. Failure to accomplish these can cause catastrophic down time and blackouts to part or all of a school division's facilities infrastructure, creating issues for wireless connectivity to the Internet, telecommunications blackouts, and instructional technology delays or failures in the classroom. This implication aligns with finding three regarding major structural components for technology infrastructure.

Implication four. School divisions need to staff their technology teams with the appropriate number of personnel to handle the demands for maintenance and upkeep of facilities infrastructure and division technology programs.

Every school division plans and hires their technology personnel differently. However, differently is not always equally. Some school divisions staff one position to do the work of two or more positions in another division. This can be problematic when technology personnel take on so many roles, that they cannot adequately meet the level of proficiency required in any of the roles they are assigned. Through a lens of time management, having to be responsible for many different roles can create a situation where technology personnel simply do not have the time necessary to successfully complete all aspects of their job. They also may not have the knowledge and skillset necessary to handle such a diverse range of job requirements. This implication aligns with finding four that discusses technology staff size.

Implication five. School divisions should hire technology personnel who possess the requisite knowledge and skills to complete their job in order to prevent outsourcing work at a higher cost.

School division technology personnel need to be well trained and able to perform a wide variety of technology installation, troubleshooting, repair, and maintenance tasks in order to be able to maintain a complex and constantly changing facilities infrastructure to support technology. School divisions who hire technology personnel that are knowledgeable and well rounded in the skillset for their hired position are able to complete their job and limit the amount of work the school division must contract to third party companies outside of the division. School divisions who cannot find qualified candidates are more likely to have a higher rate of work contracted out to third party companies at a higher cost to the division. This is due to the technology personnel not being equipped to handle the installation, maintenance, or troubleshooting of major functions and components such as servers, switches, wireless access points, fiber cabling, network configuration, and programming. The process of contracting work out to third party companies is not only more costly to the division, but can also slow down the rate of upgrades and improvements to facilities infrastructure and technology programs. This implication supports finding five, outlining the amount of work outsourced from the technology department.

Implication six. School divisions should allow for technology personnel to have the opportunity to gain additional credentialing, training, and/or professional development.

Technology personnel do not have the same opportunities for training and professional development provided by the school division as do their colleagues in the classroom. Many technology personnel rely on prior experiences, self-discovery, or other technology personnel to troubleshoot technology issues and address them appropriately. Little to no funding is set aside in division budgets for the training and professional development of technology personnel. This is despite the fact that technology is a rapidly changing and evolving area that requires almost constant application of new knowledge, equipment, and programs. This implication aligns to finding six regarding training and professional development opportunities for technology personnel.

Implication seven. Older school buildings should be purposefully monitored to combat a higher number of impediments to facilities infrastructure than in newer school buildings.

The age of a school building can have a direct impact on the volume and scope of work necessary to maintain the infrastructure within a school building. The older a school building, the more likely the cabling, hardware, and structural components necessary to maintain a modern technology initiative within the building will be obsolete, or not exist. To combat this, school division and technology leaders need to be purposeful when planning for technology initiatives with school buildings that are aging. Aging school buildings may necessitate additional funding and longer construction times when upgrading and/or maintaining facilities infrastructure. This implication supports finding seven, outlining impediments to technology depending on the age of the building.

Implication eight. School divisions should be proactive in identifying barriers to integration of facilities infrastructure to support technology initiatives, as well as quickly developing a plan to minimize and/or eliminate the barrier.

School divisions can have a wide range and depth of barriers to successfully implementing the appropriate facilities infrastructure to support technology initiatives. For many school divisions, major barriers to focus on include funding, key structural components such as servers, switches, routers, fiber and cabling, and power outlets. Another focus is undersized technology teams.

School leaders and fiscal agents for the school leaders should familiarize themselves with the necessary components to successfully run a technology program in order to be able to make informed decisions about appropriate funding levels for the division's technology budget. Failure to do so can lead to a technology program that cannot sustain an appropriate level of performance necessary to support technology initiatives within the division. Inadequate funding can cause hardware and structural components already in place to be past their life expectancies or to not be compatible with newer technology components being added to the division’s school buildings.

Appropriate structure components and power supplies should be present for major technology initiatives, such as a one-to-one device initiative, to be efficiently managed. School divisions should implement an appropriate number of technology personnel to ensure that facilities infrastructure and technology programs can successfully be upgraded, repaired, and maintained. This implication aligns with finding eight that discusses barriers to integration of technology infrastructure.

Implication nine. A technology committee should be established to openly and transparently communicate to school and community stakeholders the needs and priorities for technology within the school division.

School divisions should provide avenues for the needs and priorities for technology within the division to be communicated to multiple cross-sections of school and community stakeholders. In order for school employees and community members to understand and support the needs for technology within a school division, the school division must create narrative for the needs for planning, implementation, and maintenance of critical technology components in order for technology initiatives to be implemented within the school division. A technology committee could be the key source of information dissemination. Utilization of mailings, emails, postings on the division website and social media platforms, and community question and answer forums are all viable options for creating awareness and support for the needs and priorities of technology within the school division. This implication supports finding nine regarding the need to communicate information regarding technology to a cross-section of school division stakeholders.

Recommendations for Future Research

Based on the findings from this study, additional research regarding school facilities infrastructure and its impact on technology initiatives is necessary. Many issues and barriers were identified throughout this study. However, this study’s multiple case study design provides a relatively small sample size regarding data collection. In order to improve generalizability, additional studies should collect further data on factors such as planning, division leadership decisions, structural component upgrades and maintenance, age of school buildings, technology team size, and technology personnel training and professional development.

Planning can take many forms, and a study to investigate a more in depth perspective of how school divisions plan for technology initiatives could help add to the body of research. Another study could research what length of time is necessary to plan ahead for implementing technology initiatives. A study pertaining to division leadership decisions and their impact on technology initiatives could offer additional insight into initiatives such as a one-to-one device initiative, which has recently gained attention in many school divisions. A study focused on the need to openly and transparently pursue two-way communication with school and community stakeholders is an important future study. Additional research in the area of training and professional development for technology personnel could help determine where there are gaps that could negatively impact maintaining and upgrading a division's facilities infrastructure.

This study focused solely on rural school divisions. Additional comparative studies regarding the facilities infrastructure of rural, suburban, and urban divisions are warranted. An additional study that collects data from school divisions across the United States could show similarities and differences as to how school divisions in other geographic regions of the United States plan, build, and maintain school facilities infrastructure. The literature, findings, and implications from this study indicate that there is no consensus for how to develop and maintain facilities infrastructure within a school division; however, there are plans and strategies that are more effective and efficient than others to best prepare school and technology leaders in keeping their facilities infrastructure optimized. Each recommendation for future research is based on the findings and implications previously referenced in this study.

Reflection on the Study

This qualitative, multiple case study sought reflections of technology leaders and their personnel regarding facilities infrastructure to support technology initiatives in two rural school divisions in Virginia. A limitation of this study is that only a small sample size of participants gave feedback to be collected and analyzed as data. Not all technology team members invited to participate in the study chose to participate. One IT help desk position from Division A deferred participation, as well as one ITRT from Division B. The IT help desk person from Division A did not feel the interview questions fit the individual's job description, and the comment was made that someone needed to be available to handle any technology issues while other technology personnel were participating in the interview. The ITRT who declined to participate in Division B had just been hired and had very little knowledge about any of the technology initiatives of the division.

The research of literature and findings from this study indicate there is no consensus for how to build and maintain school facilities infrastructure to support technology initiatives. However, there are numerous commonalities in barriers to successful implementation of technology initiatives, and other common themes for best practice in how to plan and implement for facilities infrastructure to support technology initiatives. The essential components for an optimized facilities infrastructure to support technology initiatives need to include a comprehensive, yet flexible plan, an appropriate funding stream to meet the needs of the plan, an appropriate sized technology team to be able to carry out the plan, and the major structural components necessary to support the division’s technology devices and programs.

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APPENDIX A

IRB TRAINING CERTIFICATE OF COMPLETION

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Certificate of Completion

This certifies that

Michael Christopher Jarvis

Has completed

Training in Human Subjects Protection

On the following topics:

Historical Basis for Regulating Human Subjects Research

The Belmont Report

Federal and Virginia Tech Regulatory Entities, Policies and Procedures

on

November 7, 2016

David Moore, IRB Chair

APPENDIX B

IRB APPLICATION APPROVAL LETTER

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	August 30, 2017
TO:	Carol S Cash, Michael Christopher Jarvis
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)
PROTOCOL TITLE:	Reflections of School Leaders on Facilities Infrastructure Needs to Support Technology in Two Rural School Divisions
IRB NUMBER:	**17-662**

Effective August 30, 2017, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 5,6,7**
Protocol Approval Date:	**August 30, 2017**
Protocol Expiration Date:	**August 29, 2018**
Continuing Review Due Date*:	**August 15, 2018**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

APPENDIX C

COVER LETTER TO DIVISION A

Dear Superintendent or designee,

Technology initiatives are a growing part of long range plans for many school divisions across the country. However, the attention to building and maintenance of a quality school facilities infrastructure to support such initiatives has not kept pace in many divisions. Therefore, we are conducting a study on those factors that impact a school division's ability to develop a quality school facilities infrastructure to support technology initiatives. We are asking for your support in allowing an individual interview with your division technology leader and a focus group interview with county technology staff (ITRTs and System Operators). The information gained may help school divisions understand priorities and areas of need regarding facilities infrastructure to support technology initiatives.

All information will be kept confidential. School divisions and individuals participating in this study will be assigned codes to safeguard against the possibility of identification. Once the study is completed, we would be happy to share the findings of the dissertation study with your division. In addition, we would be more than willing to answer any questions that you may have about this study. We can be contacted by email (jarvis15@vt.edu) or by phone (C-804-339-2679).

In closing, thank you for your time and consideration in this matter. Have a great day.

Sincerely,

Michael C. Jarvis

Michael C. Jarvis
Graduate Student
Virginia Polytechnic Institute and State University

Dr. Carol S. Cash
Clinical Associate Professor
Virginia Polytechnic Institute and State University

APPENDIX D

COVER LETTER TO DIVISION B

Dear Superintendent or designee:

Technology initiatives are a growing part of long range plans for many school divisions across the country. However, the attention to building and maintenance of a quality school facilities infrastructure to support such initiatives has not kept pace in many divisions. Therefore, we are conducting a study on those factors that impact a school division's ability to develop a quality school facilities infrastructure to support technology initiatives. We are asking for your support in allowing an individual interview with your division technology leader and a focus group interview with county technology staff (ITRTs and System Operators). The information gained may help school divisions understand priorities and areas of need regarding facilities infrastructure to support technology initiatives.

All information will be kept confidential. School divisions and individuals participating in this study will be assigned codes to safeguard against the possibility of identification. Once the study is completed, we would be happy to share the findings of the dissertation study with your division. In addition, we would be more than willing to answer any questions that you may have about this study. We can be contacted by email (jarvis15@vt.edu) or by phone (C-804-339-2679).

In closing, thank you for your time and consideration in this matter. Have a great day.

Sincerely,

Michael C. Jarvis
Graduate Student
Virginia Polytechnic Institute and State University

Dr. Carol S. Cash
Clinical Associate Professor
Virginia Polytechnic Institute and State University

APPENDIX E
INTERVIEW PARTICIPANT LETTER

Potential Interview Participant:

I would like to invite you to take part in a doctoral dissertation study that will interview technology leaders and staff in your county. This study's purpose is to record your perspectives on the needs for school facilities infrastructure to support technology initiatives and any barriers you perceive that limit these technology initiatives.

As a public school assistant principal and former history teacher, I want to learn more about how rural school divisions work to build and maintain their school infrastructure to support growing technology initiatives. This study is exclusively for the purpose of my own dissertation through Virginia Polytechnic and State Institute and is not being led by your school division. Findings of this study will be shared with the executive leadership of your school division. Confidentiality of all individual participants, schools, and the school division will be maintained throughout all documents resulting from the study.

This qualitative case study will consist of two parts, 1) an interview where you will be asked several questions that should last approximately 45 to 60 minutes, and 2) focus group interviews where a small group of 2-4 people will be asked several questions that should last approximately 45 to 60 minutes. You will only be asked to participate in the individual or focus group portion of this study, but not both. During the interviews, all participants will be asked to discuss their perspectives on the needs for school facilities infrastructure to support technology initiatives and any barriers they perceive that limit these technology initiatives.

The interviews will not impact your contractual obligations to your school division. The interview sessions will be audio-recorded, transcribed, and reviewed. Once the audio recording is transcribed, you will be sent the transcript to review for accuracy. I will be the only person who can access the interview audio recordings and transcripts.

I do not believe that you will face any identified risks during or after the completion of this qualitative study. Your participation in this interview is voluntary and you are free to withdraw your consent to participate at any time.

If you are interested in being a part of my dissertation study, please contact me via email jarvis15@vt.edu so that we may discuss a time and location at your convenience. I hope to conduct the interviews beginning as soon as possible and finish my data gathering by Thanksgiving break. Thank you for your assistance.

Sincerely,

Michael C. Jarvis,
Ed.D. Doctoral Candidate

APPENDIX F

PARTICIPATION INVITATION EMAIL WITH DIVISION A STAFF

Focus Group Email

Good afternoon,

I would like to find out a date and time that would work in your schedules to conduct my research study interview with you all.

This focus group interview will necessitate all four of you meeting together. I would be happy to come to a centrally located building if it would be most convenient for everyone.

I have attached the interview questions for you all to review prior to the interview so everyone can have a better understanding of the types of questions that will be posed.

Prior to beginning our interview, I will ask you to review and sign an informed consent form giving me permission to conduct the interview with each of you.

Please REPLY ALL with any dates and times each of you is available in order to determine a date, time, and place that works for everyone. Thank you again so much for your willingness to participate in this study.

Thanks,
Michael Jarvis

Individual Interview Email

Good afternoon,

I would like to find out a date and time that would work in your schedule to conduct my research study interview with you. I would be happy to come to your building if it would be most convenient for you. I have attached the interview questions for you to review prior to the interview so you can have a better understanding of the types of questions that will be posed.

Prior to beginning our interview, I will ask you to review and sign an informed consent form giving me permission to conduct the interview with you. Thank you again so much for your willingness to participate in this study.

Thanks,
Michael Jarvis

APPENDIX G

PARTICIPATION INVITATION EMAIL WITH DIVISION B STAFF

Focus Group Email

Good morning,

[Your superintendent] has recently approved my research study for my doctoral dissertation to be conducted in [Division B]. If you are willing, I would like to ask for 45 minutes of your time to interview you regarding the facilities infrastructure in our schools to support technology initiatives. Please let me know if you would be interested, and if so, when you would be available. I can send you the interview questions ahead of time so you can familiarize yourself with them prior to the interview.

Thanks for your time and consideration.

Michael Jarvis

Individual Interview Email

Good morning,

[Your superintendent] has recently approved my research study for my doctoral dissertation to be conducted in [Division B]. If you are willing, I would like to ask for 45 minutes of your time to interview you regarding the facilities infrastructure in our schools to support technology initiatives. Please let me know if you would be interested, and if so, when you would be available. I can send you the interview questions ahead of time so you can familiarize yourself with them prior to the interview.

Thanks for your time and consideration.

Michael Jarvis

APPENDIX H

FOLLOW-UP PARTICIPATION EMAIL WITH DIVISION A STAFF

Good morning,

Thank you all for your willingness to participate in this interview. We have a finalized date and time of Monday October 23 at 1 pm at [Division A high school].

Please review the interview questions I attached so you can be familiar with the questions that will be asked in order to facilitate conversation during the interview. Please let me know if you have any questions between now and Monday.

I look forward to meeting everyone in person on Monday!

Thanks,
Michael Jarvis

Follow-up Participation Email with Division B Staff

Gentlemen,

Thank you for your willingness to be a part of this research study. Would Monday morning at [Division B elementary school] be possible for everyone to meet? We can meet in the conference room. I will suggest 9 am, but I am flexible if a different time is needed. I have attached the interview questions for you to review.

Thanks,
Michael Jarvis

APPENDIX I

INDIVIDUAL INTERNVIEW INFORMED CONSENT FOR PARTICIPANTS

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants in Research Projects Involving Human Subjects

Title of Project: Reflections of School Leaders on Facilities Infrastructure Needs to Support Technology in Two Rural School Divisions

Investigator: Michael Jarvis **Contact phone:** 804-339-2679 **Contact email:** jarvis15@vt.edu

I. Purpose of this Research Project

The purpose of this project is to fulfill a dissertation requirement while acquiring your perceptions on the needs for school facilities infrastructure to support technology initiatives. This study also seeks your opinions regarding any barriers you perceive that limit these technology initiatives. Your school division is not leading this study. Findings from this study will enable readers of the study the opportunity to better understand the needs for school facilities infrastructure to support technology initiatives and the barriers to integrating these initiatives. By investigating these needs and barriers to facilities infrastructure, superintendents and division-wide technology leaders will have the opportunity to develop strategies and/or a comprehensive plan to build and maintain facilities infrastructure to support technology initiatives in their schools.

II. Procedure - Individual Interview

Your participation in an individual interview will consist of answering a series of questions pertaining to school facilities infrastructure. The interview will take approximately 45-60 minutes to complete. The interview will be conducted at a time and place convenient to your schedule and will not interfere with your school division's contractual obligations. Prior to the interview, you will be provided the interview questions in order to have time to think about your responses based on your professional experiences. The interview will be audio-recorded and transcribed. You will then receive the transcripts to review for accuracy. I will be the only person with access to the audio recordings and the transcripts of the interview.

_________ (Initials) I hereby consent to allow my interview to be audiotaped.

III. Risks

There are no anticipated risks with this study.

IV. Benefits

No tangible benefits are afforded to you for participating in this study, however, the results of this study will provide the opportunity for superintendents and division-level technology leaders to identify the needs for school facilities infrastructure to support technology initiatives and the barriers to integrating these initiatives.

V. Extent of Anonymity and Confidentiality

Your identity, including all identifying names and personal information, will be removed from the collected data. A coded letter and number combination will be used in place of the names of the participating interviewees and the school systems involved in the study. Recordings and transcriptions of the interviews and focus groups will be able to be accessed only by the researcher and will be kept in a electronically locked safe. Data from the transcriptions of the digital recordings will be held in a secure, electronically locked safe and destroyed directly following the date of the successful defense of the dissertation. The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

VI. Compensation

You will not be compensated for participating in this study.

VII. Freedom to Withdraw

It is important for you to know that you are free to withdraw from this study at any time without penalty. You are free not to answer any questions that you choose or respond to what is being asked of you without penalty.

VIII. Questions or Concerns

Should you have any questions about this study, you may contact the research investigator whose contact information is included at the beginning of this document.

Should you have any questions or concerns about the study's conduct or your rights as a research subject, or need to report a research-related injury or event, you may contact the VT IRB Chair, Dr. David M. Moore at moored@vt.edu or (540) 231-4991.

IX. Subject's Consent

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

____ Date__________

Subject signature

____

Subject printed name

APPENDIX J

FOCUS GROUP INFORMED CONSENT FOR PARTICIPANTS

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants in Research Projects Involving Human Subjects

Title of Project: Reflections of School Leaders on Facilities Infrastructure Needs to Support Technology in Two Rural School Divisions

Investigator: Michael Jarvis **Contact phone:** 804-339-2679 **Contact email:** jarvis15@vt.edu

I. Purpose of this Research Project

The purpose of this project is to fulfill a dissertation requirement while acquiring your perceptions on the needs for school facilities infrastructure to support technology initiatives. This study also seeks your opinions regarding any barriers you perceive that limit these technology initiatives. Your school division is not leading this study. Findings from this study will enable readers of the study the opportunity to better understand the needs for school facilities infrastructure to support technology initiatives and the barriers to integrating these initiatives. By investigating these needs and barriers to facilities infrastructure, superintendents and division-wide technology leaders will have the opportunity to develop strategies and/or a comprehensive plan to build and maintain facilities infrastructure to support technology initiatives in their schools.

II. Procedure - Focus Group

Your participation in a focus group with 2-4 other technology staff members in your division will consist of answering a series of questions pertaining to school facilities infrastructure. The focus group will take approximately 60-90 minutes to complete. The interview will be conducted at a time and place convenient to the schedules of the members of the focus group and will not interfere with your school division's contractual obligations. Prior to the focus group, you will be provided the focus group questions in order to have time to think about your responses based on your professional experiences. The focus group will be audio-recorded and transcribed. You will then receive the transcripts to review for accuracy. I will be the only person with access to the audio recordings and the transcripts of the focus group.

_________ (Initials) I hereby consent to allow my interview to be audiotaped.

III. Risks

There are no anticipated risks with this study.

IV. Benefits

No tangible benefits are afforded to you for participating in this study, however, the results of this study will provide the opportunity for superintendents and division-level technology leaders to identify the needs for school facilities infrastructure to support technology initiatives and the barriers to integrating these initiatives.

V. Extent of Anonymity and Confidentiality

Your identity, including all identifying names and personal information, will be removed from the collected data. A coded letter and number combination will be used in place of the names of the participating interviewees and the school systems involved in the study. Recordings and transcriptions of the interviews and focus groups will be able to be accessed only by the researcher and will be kept in a electronically locked safe. Data from the transcriptions of the digital recordings will be held in a secure, electronically locked safe and destroyed directly following the date of the successful defense of the dissertation. The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

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Should you have any questions about this study, you may contact the research investigator whose contact information is included at the beginning of this document.

Should you have any questions or concerns about the study's conduct or your rights as a research subject, or need to report a research-related injury or event, you may contact the VT IRB Chair, Dr. David M. Moore at moored@vt.edu or (540) 231-4991.

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____ Date__________

Subject signature

____

Subject printed name